REPORT RESUMES

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CAREER DEVELOPMENT OF SCIENTISTS, AN OVERLAPPING LONGITUDINAL STUDY.

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THE MAJOR FACTORS AFFECTING THE CHOICE OF SCIENCE AS A CAREER WERE EXAMINED FROM ELEMENTARY SCHOOL THROUGH 4 YEARS BEYOND COLLEGE. DIMENSIONS OF INDIVIDUAL PERSONALITY AND OF ENVIRONMENT WERE INCLUDED AS STUDY ELEMENTS. THE EMPHASIS ON THE OCCUPATIONAL CHOICE PROCESS NECESSITATED A CONCENTRATION ON PERSONALITY ASSESSMENT, INCLUDING THE SUBFACTOR OF ABILITY. DEPENDENT VARIABLES USED WERE EDUCATIONAL DECISIONS AND CAREER PLANS. A 5-YEAR OVERLAPPING LONGITUDINAL DESIGN WAS EMPLOYED TO INVESTIGATE IN ONLY 5 CALENDAR YEARS THE CRITICAL 16 YEARS OF THE DEVELOPMENT PROCESS OF BECOMING A SCIENTIST. THIS WAS ACCOMPLISHED BY SELECTING 700 MALE STUDENTS FROM 5 DIFFERENT GRADE LEVELS, 3 GRADES APART. AN OVERLAP OF 2 YEARS BETWEEN EACH GRADE WAS ALLOWED, TO COMPARE THE ADJACENT GROUPS. EACH STUDENT WAS CONTACTED THROUGH BOTH INTERVIEWS AND QUESTIONNAIRES DURING EACH STUDY YEAR TO DETERMINE CAREER PLANS AND EDUCATIONAL DECISIONS. CONTACT WAS MAINTAINED WITH OVER 90 PERCENT OF THE ORIGINAL SAMPLE. DATA ANALYSIS UTILIZED SUCH TECHNIQUES AS THE MULTIPLE GROUP DISCRIMINANT FUNCTION, MULTIPLE REGRESSION ANALYSIS, AND ANALYSIS OF VARIANCE AND COVARIANCE. MAJOR FACTORS DISCUSSED WERE ABILITY, FAMILY SOCIOECONOMIC STATUS, INTERESTS, AND INTROVERSION. THE REPORT CONCLUDED THAT THESE MAJOR FACTORS AFFECTING THE PROCESS OF CAREER DEVELOPMENT WERE KNOWN AND MEASURABLE. IMPLICATIONS FOR EDUCATIONAL PRACTICE AND FOR FURTHER RESEARCH WERE PROVIDED. (JH)

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CAREER DEVELOPMENT OF SCIENTISTS
An Overlapping Longitudinal Study

Cooperative Research Project No. 436

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Cambridge, Massachusetts

1963

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PREFACE

Although this document represents the final report of Cooperative Research Project No. 436, it is viewed as the first of a series of reports on this and related investigations toward the goal of a better understanding of how, when and why boys enter careers in science and technology.

Whatever has been accomplished during the past five years has been largely due to the able assistance of graduate students working as part-time research assistants and to the aid of competent secretaries who were willing and able to learn the details of data preparation. The research assistants, and their "period of service", were:

David Berlew	1958-59	Susan Krinsky	1960-63
Ronald Dutton	1958-59	Eugene Lee	1960-62
Franklin Field	1961-62	Mona Lipofsky	1958-59
Florence Freed	1958-59	John Mierzwa	1958-61
Brete Huseth	1958-59	Edward Scanlan	1958-59
Kenneth Jones	1961-63	John Stout	1958-59

Most of their work for the project consisted of testing and interviewing. Drs. Jones, Krinsky, Lee and Mierzwa completed successful dissertations which were partially supported by the Scientific Careers Study. Ken Jones did extensive computer programming for this project, and John Mierzwa returned to Cambridge for the summer of 1963 to assist in the preparation of this report.

The project secretaries were:

Elaine Purpel	1958-60
Elinor Najita	1960-61
Naomi Alperen	1961-62
Marjorie Morse	1962-63

I am also especially indebted to Cynthia Cooley, who served unofficially as part-time secretary, data clerk, consultant, proof reader, and questionnaire "guinea-pig" throughout the project.

On July 11, 1958, a group of Harvard University faculty met as a group to discuss the general design of this investigation. Since then they have been individually contacted for advice when problems arose in their special areas. Because of their limited contact with this project, however, they must not be held responsible for its shortcomings.

John B. Carroll, Roy Edward Larsen Professor of Educational Psychology and Director of the Laboratory for Research in Instruction.
George W. Goethals, Lecturer on Social Relations and Research Associate in the Laboratory of Social Relations.
Raymond C. Hummel, Lecturer on Education.
Charles C. McArthur, Lecturer on Clinical Psychology, Psychologist to the University Health Services.
Phillip J. Rulon, Professor of Education.
David V. Tiedeman, Professor of Education.
Fletcher G. Watson, Professor of Education.

Without the initial encouragement and support of Professor Watson, this project could not have been undertaken.

Professor Carroll provided housing for this project in the Laboratory for Research in Instruction, in addition to consulting services.

Professors Anne Roe and David Tiedeman, through informal luncheons, provided a forum at which this project could occasionally be considered by researchers in the field of career development. It is hoped that their new Center for Research In Careers will provide further opportunity to pursue the research begun here.

I feel fortunate in having done this work at Harvard Graduate School of Education where Professor Rulon and his students did so much toward the development of the techniques that were found so useful in this investigation.

Much computer programming and general research consultation was obtained from Paul R. Lohnes. Conversations with him have become an essential ingredient of my research behavior.

The statistical work was done in part at the Computation Center at MIT, Cambridge, Massachusetts. We are indebted to IBM and MIT for making this facility available to New England scholars.

Finally, a great deal of gratitude goes to the 700 boys, nine school systems, and six colleges, whose cooperation in testing and interviewing made this investigation possible.

William W. Cooley

September, 1963

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FOREWORD

Career development, especially career development in science, has been the subject of much discussion and some investigations during the past decade. When, how, and by whom the decision is made to enter a career in science, rather than in technology or in any of the many other socially important careers, has been a major question. Many personal, family, school and community factors are surely at work. Increasing financial investments are being made by parents, college scholarship funds, and state and national student aid programs to encourage potential scientists as well as other potential contributors to society to continue their education as far as possible. But often neither we nor the students have a clear idea of what sorts of individuals are likely to or should end up in what sorts of careers. Thus considerable time, effort and money may be wasted in well intended but ill advised efforts.

Many investigations to explore parts of this question have been made previously. Some were based upon the retrospection of a few eminently successful scientists. Other studies have presented cross-sectional pictures of potential scientists at various times, especially as scientifically successful high school seniors. But the patterns of how these individuals reached their positions have been elusive, and the studies have generally failed to be concerned with the long term process of career choice.

Increasingly those concerned with career choice have come to view it as a developmental process. A long interval exists between the childhood "cowboy" or "policeman" stage of fantasy and the receipt of a doctorate in one of the sciences. Undoubtedly many kinds of factors are at work, with differing weights at different times. But how can a long term process be examined in a relatively brief interval so that the results will be significant in a society which is rapidly changing?

In the study presented here, Dr. Cooley has followed in five years the career choices and educational development of some 700 boys between the fifth grade and the end of graduate school. Obviously these are not all the same boys. But through the use of powerful statistical tools including multivariate analysis and discriminate functions, he has been able to study many different aspects of each boy and make general statements about the attributes of the boys at different ages who appear to be in the Potential Scientists Pool. This necessarily requires that about half of each of the five age-groups considered would NOT continue in the scientists pool, so that significant differences can be sought between those who on a few criteria look alike, for example, have comparable academic abilities and interests, yet later chose quite different careers. Through sophisticated statistical procedures and the use of very high speed computers, many complex and interesting interrelations have been examined. Some of the results confirm previous studies but other results on this sample are unexpected, raise questions about the nature of the tests used for the initial data, and provoke further investigations.

Many individuals have been involved to varying extents in this study: as parents who were interviewed, as pupil subjects, as guidance officers and deans consulted for data, as research assistants, and as friendly but at times skeptical advisers. As one of the latter, I can only report excitement with the results, appreciation for the clarity of the design and the persistence of its usage, and an admiration for those who have done the work. In an optimistic moment, I can hope that this is a milestone in the study of career development and the source of much useful enlightenment to the many deeply concerned with the development of careers in science.

September, 1963

Fletcher G. Watson

CHAPTER I
DESCRIPTION OF THE SCIENTIFIC CAREERS STUDY

In June, 1958, the U. S. Office of Education made a grant to the Harvard Graduate School of Education to undertake a five-year study of career development, with special attention to scientific careers. The general purpose of the study was to examine the process of becoming a scientist, from elementary school through four years beyond college, in order to determine the major factors affecting that process.

The understandings sought in the Scientific Careers Study required a longitudinal investigation. Longitudinal studies are the best way to confidently establish relationships between personal and environmental antecedents and consequent vocational behavior. However, few longitudinal studies have been undertaken, largely because it takes a career to follow a career and few investigators are sufficiently patient to wait that long for results. Also, there is the problem of sample size. When beginning with elementary school students, one would need a very large sample initially, to insure inclusion of a sufficient number of future scientists to allow generalizations.

The Scientific Careers Study was designed to overcome the common drawbacks to the longitudinal approach, hopefully without loss of major assets. A five-year overlapping longitudinal design[1] was employed in order to investigate in only five calendar years the critical sixteen years of the developmental process of becoming a scientist. This was accomplished by selecting 700 male students from five different grade levels, three grades apart. Table 1.1 shows the grades covered by the five groups and the number of students included in each.

TABLE 1.1

GRADES COVERED AND SIZE OF THE FIVE GROUPS

Sample Group	No. of Students	Grades Covered															
Grade 5	143	5	6	7	8	9											
Grade 8	167				8	9	10	11	12								
Grade 11	192							11	12	13	14	15					
Grade 14	105										14	15	16	17	18		
Grade 16	93												16	17	18	19	20
Total	700																

The two years of overlap between the five groups allowed comparisons among adjacent groups. It was not our desire or expectation to be able to predict which fifth graders would become Ph.D's in theoretical physics, but rather to identify factors which are related to educational and career decisions made at the various stages of development, and to be able to predict from one stage to another. Thus, trends found in one age group could be cross-validated using similar information obtained from the following age group as they moved into the same school situation.

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[1] Overlapping design adapted from approach proposed by Dyer (1956).

The five groups were sufficiently large to make applicable modern techniques of multivariate analysis in the search for general principles. However, the sample sizes were small enough to permit the careful study of individual students and their career development.

The goal of the Scientific Career Study was not toward a static description of how scientists as a group differ from other professionals or the general population, but rather toward an explanation of movement into, within and possibly out of scientific careers. The main question explored has been: What are the types of decisions one has to make in moving into a scientific career and what factors are associated with the possible outcomes of those decisions? "Factors" here included dimensions of individual personality, and also dimensions of the environment (family, school, community, etc.). However, the emphasis on the choice process necessitated a concentration of personality assessment, where personality, as used here, includes ability.

There are two general types of dependent variables in this investigation, (1) educational decisions, and (2) career plans. The first category is based upon the various types of decisions each age group is being forced to make during the five years of follow-up as they move through the schools. The other criterion is derived from the student's stated career plans and includes the stability of those career goals over a five year period. Also, the relationships between educational decisions and career plans are important, since, for example, a student may choose a course of study which would make a scientific career highly unlikely.

The effort was made in this study to predict the educational and career decisions of students from measured attributes, making full use of recent developments in personality assessment and methods of multivariate analysis. Some researchers seem to have abandoned attempts to match measured attributes with vocational decisions. However, empirical relationships between attributes and decisions are necessary prerequisites to the goal of an explanation of becoming a scientist. Student A does X because he's a Y. Our observations and computations determine the relationship between X and Y and theoretical considerations supply the "because".

A major difference between this investigation and most other studies of scientists is in regard to the question of group membership versus success in the group. We are not concerned here with what makes a good scientist, or an eminent scientist, or a creative scientist. Our concern is to identify the factors related to becoming a scientist. For example, what types of students become scientists would seem to be a question that needs answering prior to (or in addition to) a consideration of the attributes needed for success or eminence among those who stay in science. Scientists, as a group, may be so homogeneous with respect to key variables that the major factors needed for success in science may be missed. Also, if one studies only successful scientists, it is impossible to tell what is related to success and what is related simply to being a scientist.

Another contribution which a study of entrance into scientific careers might make was expressed by Roe (1950). When studying practicing scientists, you cannot decide "whether they adopted their vocations as a means to doing the things they were interested in, or became interested in the things they found themselves doing." A longitudinal approach could possibly answer this type of question.

Another way of looking at the difference between this investigation and most others is that here we are trying to predict and understand commitment to scientific careers, rather than successful performance as a scientist. If it is possible to predict commitment, much better than contributions, this might be relevant where selection is necessary. Perhaps it would be useful to select, at least in part, on the basis of who will stay in science. A person probably will not make a contribution to science if he leaves science during or right after his scientific education.

Another purpose of this investigation is to find out just how determinate the career development of scientists is, based upon what is already known. No previous study has attempted to put all that is known about becoming a scientist into one longitudinal study, and thus obtain some estimate of the variance which is still left unexplained. It was felt that we may be closer to the "necessary and sufficient" variables than is realized.

As a result, some of the "findings" reported here will certainly seem obvious to the reader. They are included because known relationships serve as a frame of reference in which to view new relationships. So much of what is reported as a "new finding" in psychology is a new label on a well established behavioral dimension, or a slight rotation of a set of well known dimensions. Also, the "obvious" results are reported along with the "novel" because there is a certain danger in attempting to anticipate what is obvious to others.

ORGANIZATION OF THIS REPORT

Because this report considers extensive details of the analyses, an outline of the report may help the reader. It is realized that readers will vary in their interest from section to section, so this annotated table of contents is offered.

The remainder of Chapter 1 is devoted to a summary of sample selection and data collection procedures. Such considerations often convey a better idea of the nature of an investigation than theoretical considerations, and so these procedural details are described first.

Chapter 2 summarizes the rationale of the investigation. The personality model and analytical techniques employed are defined, and assumptions basic to this research approach are proposed. At the end of Chapter 2 an example of a parallel research effort contrasts the inductive – multivariate approach used here with the classical deductive methods of science.

The results of the study are then reported, beginning in Chapter 3 with the middle group, the boys spanning the critical transition from high school to college. Here the factors related to entering college as a science major with career intentions of staying in science or engineering are examined. In Chapter 4 the college groups are examined to determine the factors related to choice of a particular field and type of work within science, and the problem of graduate study or not. Finally, in Chapter 5 elementary and junior high school boys are studied, exploring the extent to which trends in the other groups are discernable among younger boys. Following these three age group chapters, an integration of the primary trends across age groups is made, and a picture of this process of becoming a scientist is begun in Chapter 6. Here the major results of Chapters 3, 4 and 5 are brought together and compared with each other.

A formal review of the literature upon which this investigation was based will not be presented here, as it is available elsewhere (Cooley, 1958). However, in Chapter 7 the results of this investigation are related to the findings of other studies. Chapter 7 also draws implications of the project. Three areas are considered: scientific education, guidance, and future research in career development of scientists.

Several appendices are included which report research efforts which were parallel investigations to the main study. Those were primarily doctoral studies supported in part by funds from the Scientific Careers Study.

Selection Of Schools and Students

One of the first tasks which faces an investigator who intends to examine aspects of human behavior empirically is the selection of the subjects to be studied. The following section of this report describes the procedures used in the selection of the students and the reasons for choosing those particular procedures.

SELECTION OF NINE SCHOOL SYSTEMS:

One of the major practical objectives of this study was to determine how to provide reliable information with which students can make more realistic educational decisions. It is not our intention to end up with normative data for immediate use in the schools, but rather to determine what type of normative data might be useful and feasible. For this reason, it was decided that a strict random sample of the student population was not necessary. However, a variety of schools and communities seemed to be desirable, not only to provide more representative findings, but to minimize the danger of over-taxing the patience of any one school system (an important consideration for a five-year study). A practical necessity was to use schools within a 25-mile radius of our center of operations, Harvard University. Since it was necessary in our design to draw students from three different grade levels within any given system, private schools were eliminated. Another reason for that decision was our desire to minimize the number of external variables in this study, yet still be able to generalize beyond one particular community. Finally, it was decided that about ten school systems would make it possible to keep the number of boys to be tested at any one time and place below thirty, thus minimizing the difficulties involved in scheduling tests, finding space for the testing, provision of testing materials, etc.

Using the above rationale, the nine school systems were selected in the following manner. Fifteen communities were randomly chosen from those within a twenty-five mile radius of Cambridge. Two communities without their own high schools were eliminated and the remaining list was discussed with Harvard faculty familiar with

TABLE 1.2

THE PARTICIPATING SCHOOL SYSTEMS
(figures available September, 1958)

City or Town	Superintendent	Pop. 1955	Average Daily Attend.	Pupil-Teacher Ratio	Cost Per Pupil
Somerville	L.C. Donahue	97,000	10,760	23.3	$303
Brockton	E.A. Nelson	63,000	10,495	28.5	212
Framingham	R.N. Anketell	32,000	6,192	26.7	273
Winchester	H.V. Gilson	18,000	3,462	26.7	305
Wilmington	J.J. Collins	9,400	2,421	29.0	201
Maynard	A. Lerer	7,000	1,221	26.1	210
Weston	A.G. Brackett	6,000	1,610	22.3	327
Millis	G.C. Roy	3,030	777	26.8	218
Stow	R.C. Glidden	2,200	462	25.3	234

the schools in this area and with personnel at the Massachusetts Department of Education to obtain opinions on any schools which might present difficulties during a longitudinal study such as this, and to make certain that variety was achieved. Ten communities were selected as a result of these discussions. One additional school system was recommended because of its proximity to Harvard, but it was not possible to secure their cooperation, and so no additions were made to the original list.

The superintendents of these ten systems were personally contacted during July, 1958 and all agreed to cooperate with the project. It was learned that the smallest community contacted did not have any eleventh grade boys who met our selection criteria, and so only the remaining nine were used. An idea of their relative sizes and certain economic factors can be obtained from Table 1.2 above.

SELECTION OF THE COLLEGES

Some of the desired analyses involved comparisons between adjacent age groups. For instance, it was important to find out if equations developed from the analysis of test data for the college senior group would predict certain aspects of vocational behavior for the sophomore group as they reached that stage of development.

For such comparison purposes it was desirable to draw the college students from the colleges which the graduates of our nine school systems most frequently attend. This information was secured from the nine cooperating high schools, and the colleges most frequently attended by their graduates were: Northeastern University, Tufts University, Boston University, University of Massachusetts, Boston College, Massachusetts Institute of Technology, and Harvard University (in order of frequency). The University of Massachusetts was eliminated because of its distance from Cambridge. The appropriate deans of the other six colleges were contacted. All agreed to cooperate.

SELECTION OF THE STUDENTS

Since the focus was on entrance into careers in the field of science and technology, it was necessary to include enough "future scientists" for analysis purposes. However, it was neither desirable nor possible to include only those heading toward scientific careers for this would make comparisons impossible. It was, therefore, decided to utilize what was already known about scientific careers and eliminate certain segments of the school population for which entrance into scientific careers was extremely unlikely.

Unlike some occupations, one does not simply "end up" as a scientist. That is, there are certain decisions required as one moves through our schools, and if certain alternatives are chosen, a career in science is highly unlikely.

Each of our five age groups were selected by using what was known about the Potential Scientist Pool (PSP) at that stage of development. (Cooley, 1958). The PSP defines the pool of boys who could pursue professional careers in the fields of science and technology. "Could" because they have attributes consistent with those known to be needed for continued professional training and because they have made educational decisions which do not prevent education in science and mathematics. The PSP, then, includes the future scientists and also their classmates for whom science careers are still possible but who will eventually decide on other careers. The criteria for deciding who is in the PSP can be more specific for college students than for fifth graders;

but even those previous criteria include many more people than do actually continue careers in science. One result of the Scientific Careers Study is that more specific statements for defining the PSP at the various stages of development are now possible.

Eligibility was determined by use of the following selection criteria:

1) Since the process of vocational development for girls is considerably different than it is for boys, and since girls tend not to go into scientific careers, it was decided to include only boys. To study girls also would have required doubling the entire operation, since girls' data must be kept separate from boys' data.

2) All fifth and eighth graders selected were above the 50th centile on all previously administered tests of general intelligence.

3) All eleventh graders were above the 50 centile in general intelligence and school achievement and were taking the college preparatory curriculum.

4) The college boys were all majoring in science, mathematics, or engineering, and graduated from public high schools for which our nine school systems are representative (eastern Massachusetts).

SECURING STUDENT AND PARENT COOPERATION:

It is one thing to draw 700 names from a "hat" of eligibles, but it is quite another to get those selected to agree to cooperate. No difficulty was anticipated nor received from the 500 fifth, eighth, and eleventh grade boys, since school time was used and few boys mind being taken out of a class, even for psychological testing. To secure parent cooperation, the letter in Appendix A1 was distributed. Only one parent refused to allow his son to participate.

The college groups were more troublesome. The letter in Appendix A2 was sent to 342 college boys. Because of pressures of class schedules (especially severe among science students with their large laboratory commitments), only 269 of those contacted agreed to take the tests, and 195 finally completed all testing and interviews. There are partial or complete data on a total of 217 college boys. The 78% return on the college group limits the representativeness of our sample of science majors. The only known bias is that engineers are under-represented in this sample.

Data Collection

Once the cooperation of the 700 boys was secured, the large task of testing and interviewing each school boy in the three grades at the nine different school systems, and the two groups of college boys at the six different colleges was begun. Because our procedures might be of interest to other research workers faced with similar problems, a brief description is included below. This is followed by a description of the instruments used.

SCHEDULING AND TESTING PROCEDURES:

Each testing session was administered by one of our staff members. Six part-time research assistants were assigned one or two communities, with the responsibility to schedule and complete all testing for that school system. Each school presented peculiar scheduling difficulties and these were worked out between the staff member and our contact at that school, usually the principal or guidance director. The usual procedure involved scheduling one class period of testing for each of these three grades in a community for one day and then making about four or five such trips to each community. In this way, the testing was not too concentrated for any individual or school, yet travel to the communities was not excessive. The school testing was begun in October and was completed by the second week in December.

The Rorschach and career interviews conducted in the schools presented very few difficulties. If several interviewers were operating in the same school building on the same day, suitable space occasionally presented difficulties. Only a few schools are equipped with conference rooms, so the interviews were conducted under varying, but adequate, conditions. (In fact, the cooperation was so good that at times the principal gave up his office for a morning so that the interviews could be conducted in private!)

The college testing was more difficult. The deans could only agree to let us contact their students, but the task of getting them to come to the right place at the right time was ours. The general procedure included obtaining everyone's class schedule (requested of them in our first letter) and finding days during which most of them had at least one free hour. Post cards were then mailed to the students asking them to come to the testing room (on their own campus) sometime during that day. Only one of the tests was timed, so the testees could come and go at their convenience. "No-shows" were telephoned and encouraged to come to the next arranged testing day. About eight such sessions were necessary to complete the group testing at each college. Individual Rorschach interviews were scheduled at the group sessions or by telephone. These interviews were also conducted at each campus, the average time being about one hour per student. Greater cooperation was achieved with individually assigned interviews than with the group testing sessions.

INSTRUMENTS USED:

The decisions regarding which tests to use during the first year's testing program were based upon the consideration of several factors. Previous research served as the major basis for deciding which areas demanded attention. The standardized tests which would contribute information in the desired personality and ability areas were then chosen largely on the basis of their characteristics as reliable measuring instruments and their general availability (so that others might easily duplicate these procedures).

The environmental information was secured by questionnaires and interviews of our own design. The particular items composing these instruments were also based upon previously observed group tendencies for scientists and engineers, and also from studies of college attendance. The testing program is outlined below. Copies of the mimeographed material can be found in Appendix A.

In the following lists, a code like 5:8 is used to define a test administration. Thus, "5:8" reads, the original grade 5 group at grade 8.

Fifth Grade Group

5:5

STEP Science Test, Form 4A

STEP Mathematics, Form 4A
STEP Reading, Form 4A
Reed Activities Index (Designed to measure the extent of voluntary student participation in science type activities.)
Home Scale. (A mimeographed check list which gives an index of socio-economic status.)
Student Questionnaire. (Family and personal background, school activities.)
Parent Questionnaire.[1] (Family background, parental employment and activities, and their career hopes for their son.)
Interview and Projective Testing. (Questions and selected TAT cards were designed to yield information about authority and affection figures and role models. Individual standardized Rorschachs were also administered.)

5:6

IPAT HS Personality Questionnaire
Otis Quick-Scoring Mental Ability Test
Follow-up Questionnaire

5:7

Follow-up Questionnaire

5:8

IPAT HSPQ
STEP Mathematics, 3A
STEP Science, 3A
Interview

5:9

Follow-up Questionnaire
Reed Activities Index

Eighth Grade Group (No explanation is given where items are similar to those explained in the fifth grade list.)

8:8

STEP Science, Form 3A
STEP Mathematics, Form 3A
STEP Reading, Form 3A
Reed Activities Index
Home Scale
Student Questionnaire
Parent Questionnaire
Student Interview (Sought information about the student's present spare-time activities, in-school activities, career plans, self-ratings, and interpersonal relations.)

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[1] There was 98.6% return on the 300 parent questionnaires. The initial request letter is in Appendix A. Post cards, phone calls, and personal visits were used in the follow-up.

8:9

IPAT HSPQ
Otis Quick Scoring Mental Ability Test
Rorschach Test
Interview

8:10

Follow-up Questionnaire

8:11

Kuder Preference Record, Vocational
Guilford-Zimmerman Temperament Survey
California Test of Mental Maturity
Interview

8:12

Follow-up Questionnaire

Eleventh Grade Group

11:11

STEP Science, Form 2A
STEP Mathematics, Form 2A
California Test of Mental Maturity, Short Form
GZ Temperament Survey
Kuder Preference Record, Vocational, Form CM
Home Scale
Student Questionnaire
Student Interview. (Similar to one used for eighth grade students)
Parent Questionnaire

11:12

Work Value Questionnaire
Test on Understanding Science
Follow-up Questionnaire
Rorschach Test
Teacher Ratings

11:13

Follow-up Questionnaire

11:14

Allport-Vernon-Lindzey Study of Values
Strong Vocational Interest Blank
Follow-up Questionnaire

11:15

Follow-up Questionnaire

College Groups

14:14 to 16:16

Strong Vocational Interest Blank for Men, Revised.
Guilford-Zimmerman Temperament Survey
Allport-Vernon-Linzey Study of Values
Thematic Apperception Test. (Six-picture form devised by
David McClelland. It is a group administered test
These are scored for three motives: Power, achievement
and affiliation.)
Standardized Rorschachs. (Individually administered.)
Home Scale
Student Questionnaire
CEEB Scores and High School and College Transcripts

14 to 18

Follow-up Questionnaire each year

16 to20

Follow-up Questionnaire each year

This introductory chapter has simply been a brief description of the nature and intent of the Scientific Careers Study, followed by a description of procedures used. In Chapter 2 are provided the reasons for these procedures and for the analyses which follow Chapter 2.

CHAPTER 2

THEORETICAL AND ANALYTICAL CONSIDERATIONS

In this investigation, career development is considered to be a part of personality development. The primary aspects of career development which are of concern here are the educational and vocational decisions which one makes in going from elementary school through college and out into the first work situation. These decisions are assumed to be in part a function of the individual's personality.

In this context, personality is defined as the conceptual scheme used to interpret previous responses of the person, and to anticipate future responses. Personality is a theoretical interpretation of the person's behavior which is derived from all of his previously observed behavior. This definition of personality follows McClelland (1951), and includes intellectual functioning.

Many different types of conceptual schemes have been advanced for dealing with personality. Different theories of personality are necessary because psychologists make many different types of observations and measurements, and deal with many different kinds of problems.[1] The theory of personality adopted for this investigation is a factor representation of human behavior. Although factor theory may or may not be useful, for example, in understanding and dealing with mental illness, or for dealing with and explaining change in personality, factor theory does seem to be a particularly operational scheme for describing the current personality of a person. That is, over short periods of time, factor theory serves as a useful and economical model to account for the previously observed sample of behavioral responses and to predict what the likely responses are to be in the near future. The length of time over which predictions would be valid would depend upon the relative stability of the individual's personality under investigation, and the type of prediction attempted.

Before this theoretical position can be further developed, it is necessary to explain the test space concept, and the probability classification procedures which are the analytical techniques employed extensively in the factor approach used here.

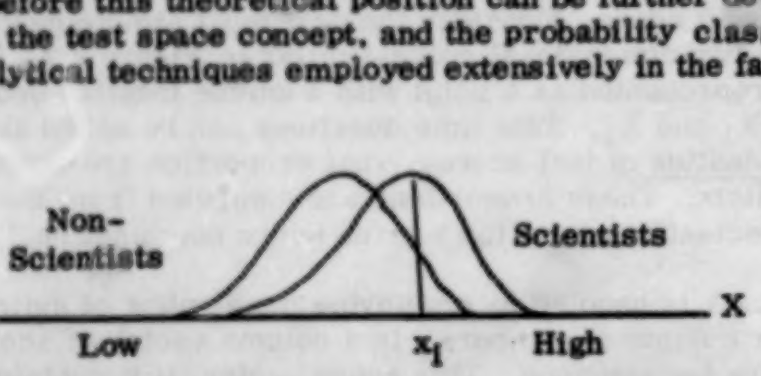

FIGURE 2.1
A ONE-DIMENSIONAL TEST SPACE

Figure 2.1 represents a one dimensional test space. An individual's location along axis X depends upon his score on test X. The height of the curve for the scientist group at some point, for example at x_1, is the frequency with which scientists receive that particular score on X. Knowing only the test score, you would predict that the person was a non-scientist if the score was low, and a scientist if the score was high. Knowing the heights of the two curves at score x_1, it is possible to compute the proportion of people receiving that score who are scientists, and the proportion who are non-scientists. With new test scores, from a person for whom the scientist: non-scientist designation is unknown, the proportions become probabilities of group membership for that person.

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[1] Psychologists are not unique in this diversity. The theoretical model of the atom which the classical physicist uses in studying the behavior of gases is quite different from the one used by the chemist in studying chemical bonding, and both of these differ from the atom of the nuclear physicist.

For example, if one-third of the people having a score of x_i are non-scientists, and two-thirds are scientists, then the probability that a person with score x_i is a scientist is .67 and .33 is the probability of non-scientist. This assumes that the two categories exhaust the possibilities for the population under consideration. If the areas under the two curves are equal, this also assumes that the two groups exist in equal numbers within that population. These two conditions,(that there are only two categories of people in the mixed population and that they are of equal frequency), are peculiar to this example and are not limitations of the technique.

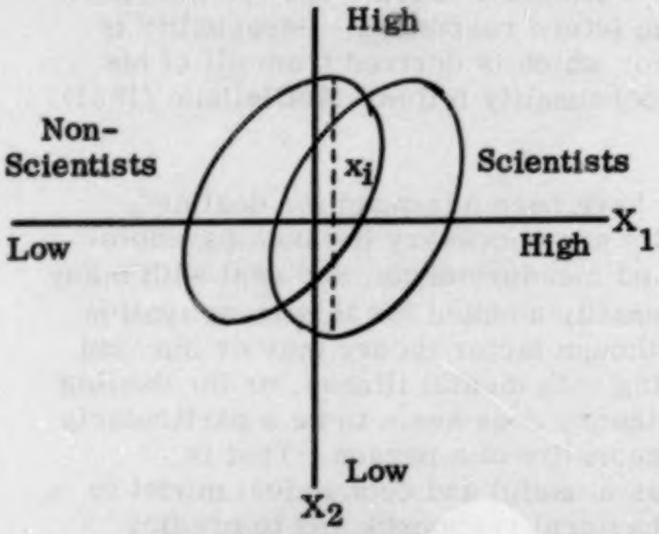

FIGURE 2.2
A TWO-DIMENSIONAL TEST SPACE

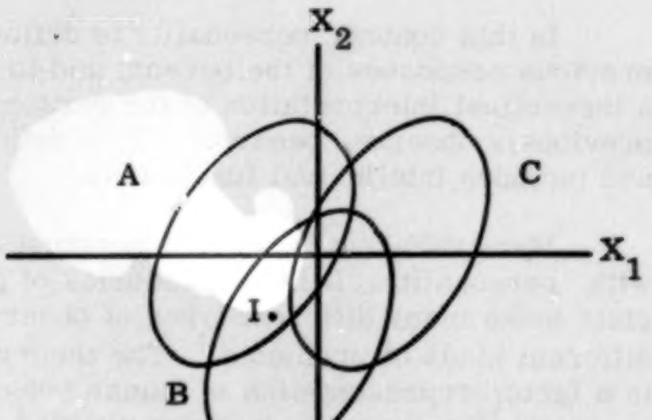

FIGURE 2.3
THREE GROUP DISPERSIONS IN A TWO-DIMENSIONAL SPACE

Of course, a single test score yields inadequate information, so a method is needed for handling more than one test score. Consider the next most simple case, that of two tests. This results in a two dimensional space similar to Figure 2.2. In this space, each individual can be represented as a point with a unique location depending upon his combination of scores on X_1 and X_2. This time questions can be asked about people receiving a particular combination of test scores: what proportion are scientists, and what proportion are non-scientists. These proportions are computed from the frequency of scientist points and non-scientist points for a given score combination.[1]

Mathematically the analytic task is handled by employing the algebra of matrices and vectors.[2] A vector is a row or column of numbers. In a column vector of scores, each number represents a test score for someone. This score vector, if it contains m-scores, locates an individual in an m-dimensional space. If there are N such vectors, representing N people sampled from a population, the region of the test space occupied by that population can be estimated from the sample by assuming that the distribution of points in the population is multivariate normal. The center of the swarm of points is represented by the vector of sample means (called the centroid), and the dispersion of the points about the centroid is described by the variance-covariance matrix.

For the two-dimensional example of Figure 2.2, the dispersion matrix for the scientist group is:

where S_1 is the standard deviation for variable 1 and r_{12} is the correlation.

$$\begin{bmatrix} s_1^2 & r_{12}s_1s_2 \\ r_{21}s_1s_2 & s_2^2 \end{bmatrix}$$

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[1] For computational procedures, see Cooley & Lohnes (1962)

[2] See, for example, Horst (1962)

This technique has been generalized to any number of groups using any number of variables, each new variable adding a new axis to the system. For example, the bivariate normal distributions for three groups on tests X_1 and X_2 are outlined in Figure 2.3. Once the means and dispersions of these three groups have been estimated, the probability that individual i is a member of group A, B, or C can also be estimated.

The computations become rather extensive as the number of variables increases, but this is where discriminant analysis is useful. With this technique it is possible to reduce the number of dimensions needed to describe the differences among the G groups (a maximum of G-1 dimensions are needed for describing the G group differences). Looking back at Firure 2.1, the X axis could represent a discriminant function, and an individual's location along this derived axis would be determined by his particular pattern of test scores, not simply a single test score. If six test scores had been used, such as the six scales in the Allport-Vernon-Lindsey Study of Values, an individual's location on discriminant function X would be determined by a weighted sum of his six scores. The weights are chosen so as to maximize the ratio of variation among groups to the variation within groups. The pattern of test scores which would result in a high score on function X (or membership in group B) can be determined by inspecting the derived discriminant weights. The one-dimensional discriminant space would then be used to predict group membership, rather than the six-dimensional test space. Similar predictions would result from either space, (Lohnes,1961), but predictions based on one dimension are much faster to compute.

The number of discriminating dimensions which result from a discriminant analysis can also be revealing. If only one function results, it indicates that there is only a quantitative difference among groups. That is, only one patterning of scores made a difference, and the groups differ in degree along this single function. If a domain under consideration yields two functions, then the groups can be said to have qualitative differences. That is, more than one pattern of scores can be used to describe the group differences. The number-of-functions question is essentially this: Do the G groups exhibit the same relative differences for each variable in the domain? If they do, only one function results. Chapters 3, 4, and 5 provide numerous examples of this aspect of discriminant analysis.

Returning to the factorial conceptualization of personality used here, personality has its locus in an m-dimensional space. A person's personality is his unique location in this space, the location determined by the total pattern of behavorial measures which are available for that person. People who have similar patterns of test scores (or factor scores) will occupy similar regions of this m-dimensional space. That is, people who behave similarly have similar personalities. People with similar personalities tend to make similar types of career decisions. Once the regions of the test space or discriminant space occupied by people making particular types of career decisions are defined, the probability that a new person will make a certain decision can be estimated.

Basic Propositions

The differences among individuals which result in different choice behaviors in the course of their career development can be adequately described by locating individuals as points (or vectors) in a multidimensional space. For reasons to be explained later, at least two types of spaces are required:. 1) a personality space, the coordinates of which are determined by sampling responses to verbal and visual stimuli, and 2) an environmental space, the dimensions of which are determined by sampling conditions in the individual's environment. The personality or behavioral space would be defined by factors from the domains of ability, interest, values, temperament, and motives, whereas the environmental space contains factors based upon such information as father's occupation, parent's expectations for child, school opportunities, home climate, religious and ethnic group membership, sex, etc. Methods of multivariate analysis can be used to reduce either space to the minimum number of dimensions needed to describe the differences among individuals, or among groups of individuals making similar types of decisions, so that a large mass of data can be reduced to a more manageable size.

Location in a certain region of the behavioral space describes the individual's personality, of which choice behavior is one aspect. For example, if a decision between two alternatives has been made by individuals located in the behavioral space, such as A) college preparatory curriculum, and B) non-college preparatory, the behavioral space will contain regions in which many individuals chose A over B, other regions in which choice B was preferred to A. There may be at least some A choosers in all regions of the personality space, but the A density varies from region to region. Comparison of the density of A choosers to B choosers at a particular point in the space determines the probability that choice A will be made by persons at or near that point. This scheme of analysis is generalizable to situations involving more than two decisions.

Location in a certain region of the environmental space is a function of those conditions in the environment which are likely to affect educational and career decisions. As in the behavorial space, the density of points representing a particular choice varies from region to region of the environmental space. Location in the environmental space is related to choice behavior for two reasons:

(1) Different regions of the environmental space tend to reinforce certain behaviors more than others. This environmental effect will in part determine the individual's personality.

(2) Different regions of the environmental space also affect choice behavior directly, without necessarily affecting verbal responses to test stimuli. This is because certain environmental variables, such as socio-economic status of parents, affect choice directly by limiting some choices, or expediting others.

If the career decisions are primarily a function of location in a behavioral space, the problem remains of finding the biological and environmental factors which determine the individual's personality. Of course, one's biological equipment is an important determiner, but the concern here is with the use the person makes of the biological equipment he has, not its description. We must leave to others the establishment of relationships between biology and personality.

The other determinant of personality is environment. In the investigation of the relationships between location in the environmental space and the behavioral space, learning theory may be especially useful. Except for the thesis investigations of Jones (1963) and Krinsky (1963) the Scientific Careers Study has not focused upon this environmental problem. However, now that we have identified regions of the behavioral space which are related to particular types of choices, a full scale attack on this problem seems to be a logical step.

DEVELOPMENTAL STAGES

Since learning occurs continuously, it is possible that the relative locations of individuals in the behavioral space will change over time. For this and other reasons previously outlined (Cooley, 1958), it is necessary to break the process of career choice into stages. In this investigation, the formal developmental stages postulated by Super etal (1957) and others were not considered necessary. Instead, gross chronological stages were used, based upon the decision points which are encountered as one moves through our schools and into work situations.

During the extended period of time during which one "becomes" a scientist, prediction is directed toward the next stage of development rather than to some hypothetical "final" occupation. The assumption is that the relative positions of individuals in the behavioral and environmental space is sufficiently stable to allow predictions of choice over a four or five year span. That is, the changes in personality which do occur over such a period are fairly uniform over all persons, so that their positions, relative to each other, do not change.

In the type of complicated choice process under consideration, at the early stages of development the alternatives are grossly categorized in some fashion and a decision is made from among the gross categories; the alternative chosen is further categorized and a second decision is made; etc. This process of refinement takes place over an extended period of time. Thus "I want to be a scientist" at age 10 can become "chemist" at age 16 and "research biologist" at age 21.

At early stages (grades 5- 12), it seems unreasonable for the investigator to take at face value a specific occupational preference, such as biochemist, and attempt to distinguish between boys who say biochemist and other boys who say engineer. Because specific goals are so unstable during these early years, it seems reasonable to assume that what the boy has done is identify a broad area of interest and the specific is more circumstantial than anything else.

Since a boy will seldom define a specific occupation before high school graduation, and if he does, it is a fairly unstable goal, natural science as a broad occupational area (both pure and applied) is considered as an undifferentiated field up through high school. Only after entrance to college does the student (and hence the researcher) need to consider more specific criterion groups.

THE IRREVERSIBLE NATURE OF CERTAIN DECISIONS

Although the decision to embark upon a scientific career cannot be considered as a single event occuring at some point in time, certain crucial educational decisions, which are forced at several stages of educational development, affect the career possibilities in science and technology open to an individual when he terminates his education. Because of the specialized nature of work in science and technology, after a certain stage of development is reached (perhaps somewhere in senior high school), changes in the potential scientist pool (PSP) are essentially a one-way proposition – out. The point at which the PSP reaches its "recruitment limit" has been examined in this investigation.

PROBLEM OF ARBITRARY CRITERIA

Most previous efforts toward predicting vocational behavior have attempted to distinguish among occupational groups on the basis of certain measurements made of members working toward or in those occupations. Numerous group tendencies have been observed, but these relationships are so slight that they have almost no predictive value. In an effort to take into account the multiple test score information of individuals, methods of multivariate analysis have been employed and prediction has been improved a little, but efforts to include more and more observations on more and more variables (which proved possible with the advent of the electronic computers) have often been disappointing.

One method by which prediction might be improved is to seek criterion groups more homogeneous with respect to the measurement procedures available. There is, after all, nothing sacred about any scheme for classifying occupations. As Bruner and others have pointed out, "Science and common-sense inquiry alike do not discover the ways in which events are grouped in the world; they invent ways of grouping. The test of the invention is the predictive benefits that result from the use of invented categories.[1] There is no reason to be bound by occupational categories which were not evolved for purposes of predicting vocational behavior. Of course, if one is interested in the technology as well as the science of this process, categories must be functional for guidance purposes. To tell a person that he exhibits "type Q" vocational behavior will be of little value if that does not provide him with information for making certain educational decisions, such as choice of college major. But perhaps it is possible to devise functional criteria which are related to measurable attributes, rather than continue to search in vain for instruments which can predict eventual membership in arbitrary categories such as those defined by the Dictionary of Occupational Titles.

DEVISING CRITERION GROUPS

The problem of defining "similar kinds of career goals" is a rather difficult task. But it is still necessary to decide what types of career goals are to be included in group A if one wants to make statements like: "People like you, John, who have tried to become an A in the past have tended not to continue toward that type of position." The following two criteria for a suitable grouping procedure seem to outline what is needed.

1) The occupational groups must be relatively homogeneous with respect to the predictors being utilized. We could not expect to work out a useful prediction of probable group membership if one group (e.g. scientists) exhibited the same density in all regions of the predictor space as did other groups (e.g. musicians, businessmen). It is necessary to use variables which are functionally related to membership in the various groups, and homogeneity is a necessary if not sufficient condition for the establishment of functional relationships.

2) The preparation required of people occupying positions in a group must be considered in defining the group. This seems reasonable since the purpose of the entire operation is to provide information for making decisions about alternatives presented during the educative process. This suggests that it may be desirable to develop less specific types of categories for the earlier stages of development.

Using these criteria for grouping, several published classification schemes were considered but none seemed completely satisfactory for one reason or another. Also, several empirical grouping procedures were examined which resulted in very homogeneous groups, but again the results were often uninterpretable and the grouping process seemed too laborious or artificial. The solution reached was to reconsider the criterion question at each stage, arriving at groupings which seemed consistent with age, types of possible decisions, and the information available in the predictors. How this worked in practice can be seen in Chapters 3, 4, and 5.

CAUSE AND EFFECT

In addition to an interest in prediction, this investigation attempts to piece together a convincing explanation of entrance into scientific careers. "Explanation" generally implies becoming involved in a discussion of cause and effect. A difficulty here is that only survey type data are available -- correlations, group differences, etc. The inveterate experimenter suggests that one had better stop at description with this type of data. Unless a variable is actually manipulated and corresponding changes are observed in B, there is a risk of talking about cause and effect when in reality both variables are a function of C, and the observed correlation between A and B is the effect of the unobserved C.

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[1] Bruner et al. (1958, p. 7).

However, if the vocational psychologist accepts this argument, he will not obtain a satisfactory explanation of vocational behavior, at least not in the near future. It is difficult enough to convince people that it isscientifically important that they be observed and tested in longitudinal studies of career development. Few would be ready to be systematically manipulated in experiments, or randomly assigned to homes, schools, curriculums, colleges, jobs, etc.!

Although it might not be possible to study cause and effect experimentally in career development, it is certainly possible to provide an explanation of movement into scientific careers which is consistent with these data. Furthermore, in any scientific explanation it is the model which supplies the "because", not the data. In this investigation a model is sought which is consistent with the reported observations.

SUMMARY

A summary of the basic propositions presented above may be useful before turning to a comparison of another type of rationale which has guided others in this area of research.

1. Career choice is a function of the person's personality.

2. Many behavioral factors need to be considered in combination, in a "factor" space model, before one will understand or predict entrance into scientific careers. Personality is treated as an m-dimensional space.

3. The differences among individuals which result in different choice behaviors can be adequately described by locating individuals as points in a multidimensional behavioral space.

4. Proposition (2) assumes that location in a certain region of the behavioral space reflects the individual's personality, of which choice behavior is an aspect.

5. Because different personality patterns are possible for each type of choice, and because random environmental variables are operating over the period of prediction, predictions can only be made by assigning probabilities to the possible choices.

6. Environmental factors in part determine location in the behavioral space and also affect choice directly.

7. Because the process of becoming a scientist takes place over an extended period of time, and because differential learning may change the relative location of individuals in the behavioral space, prediction is directed toward the next stage of development.

8. After a certain stage is reached, changes in the membership of the PSP are essentially one way – out.

Although selected aspects of the above statements can be tested, these propositions certainly do not represent a tight deductive scheme capable of being subjected to "critical experiments". These propositions do not form a theory in the classical scientific sense. What has been described is a research procedure which has yielded some empirical evidence upon which a suitable theory may eventually be based.

In the following final section of this chapter, the rationale used in this investigation is compared to another theoretical approach which has been used in the study of scientists.

The Classical Deductive Model

In this research project, the process of "becoming a scientist" is considered to be multivariate in nature. That is, many factors need to be considered simultaneously before one will "understand" or predict this process. This makes the theoretical task difficult because of the influence which classical deductive models have had on our ways of thinking about phenomena.

For example, the following *type* of hypothesis is sometimes proposed in this field of inquiry: "The future scientist is *simply* a boy who resolves his guilt over love of his mother and hatred of his father by early and complete identification with his father, probably in the phallic period."[1] The main problem is the univariate-cause-and-effect nature of the statement. McClelland is apparently seeking a necessary condition for (or a common explanation of) becoming a scientist.

An examination of the basis for McClelland's hypothesis may clarify the possible difficulty. This example is well adapted to this purpose since McClelland did a splendid job of describing the consideration which led to his hypothesis. His discussion is a good illustration of the classical deductive methods of science.

First of all, he summarized what he felt were well-established facts. He listed and discussed the following observations:

1. Men are more likely to be creative scientists than women.
2. Experimental physical scientists come from a background of radical Protestantism more often than would be expected by chance, but are not themselves religious.
3. Scientists avoid inter personal contact.
4. Creative scientists are unusually hardworking to the extent of appearing almost obsessed with their work.
5. Scientists avoid and are disturbed by complex human emotions, perhaps particularly by interpersonal aggression.
6. Physical scientists like music and dislike art and poetry.

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[1] McClelland (1962, p.153) (Itallics are mine.)

7. Physical scientists are intensely masculine.

8. Physical scientists develop a strong interest in analysis, in the structure of things early in life.

McClelland's next task was the very difficult one of arriving at a single hypothesis which could explain all these observations, drawn from the psychological theories familiar to him. No philosopher of science or psychologist has ever adequately described just how a scientist accomplishes this aspect of his work, but eventually, at least among successful scientists, an hypothesis emerges which can be derived from some theoretical scheme and which fits the known facts. In this case, it was the Oedipal hypothesis. Given the hypothesis and the psychoanalytic theory upon which it is based, it is possible to deduce the eight observed generalizations. It is also possible to deduce new, previously unobserved generalizations, and these serve as the basis for future researches in classical deductive science.

What is wrong with seeking a necessary condition for a particular career choice? First of all, consider the nature of the "facts" upon which the whole scheme rests. These characteristics of scientists are group trends. Variables are reported which exhibited differences between scientists and a suitable comparison group. The problem is, the overlap between groups is generally so extensive that the results based upon a composite of univariate trends may be distorting. On each variable, different individuals may have forced the scientist group mean away from the population or control group mean.

For example, take two of McClelland's generalizations, numbers (6) and (7). Assessing the musical interest and masculinity of a random sample of physical scientists, one finds their means are "high". This places the group centroid (.) in the ++ quadrant (upper right), if the axes pass through the population means. Hence, generalizations (6) and (7). But what about the dispersion about these means? Figure 2.4 represents the probable general outline of such a two-dimensional dispersion.

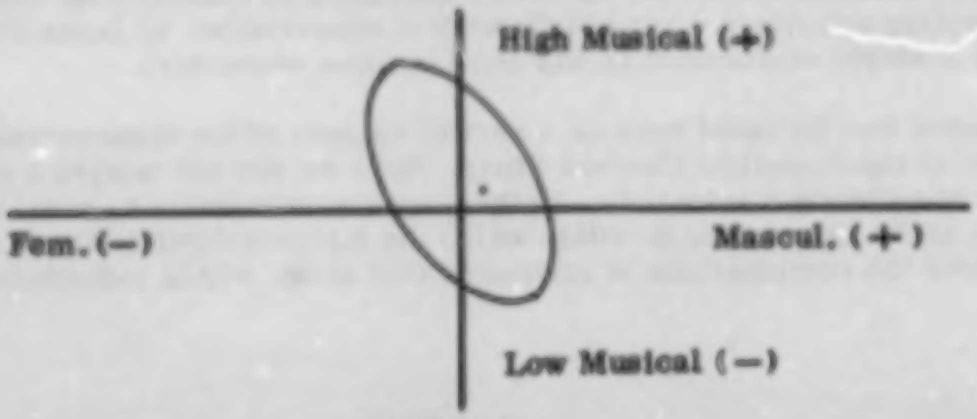

FIGURE 2.4

All the information available on these two types of scales indicate that the correlation is negative. It is probably also negative for a group of scientists. (In the SCS data the Kuder musical and GZ masculinity was -.21 for N = 190).[1] The only scientists which McClelland's hypothesis could be referring to, at least as far as generalizations (6) and (7) are concerned, would be those in the + + quadrant. Those in the - + quadrant (upper left) produced the high musical mean, those in the + - quadrant (lower right) produced the high masculinity mean. Surely, then, there is some difficulty with any hypothesis based upon generalizations (6) and (7). The problem is even greater when all eight axes are considered.

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[1] Actually, the dispersion is what is relevant, not the negative relationship.

An analytical device is needed for combining information from several variables, one which will keep track of the combinations which tend to occur within individuals. It is important not to attribute to all scientists those attributes which are found among a sub-set of scientists.

Another problem in seeking a necessary and/or sufficient condition for group membership based upon univariate trends is that important determiners of membership may not be revealed by an examination of group means. Consider two variables, X_1 and X_2. Scientists have a higher mean on X_1 but no difference are found for X_2. If there is a positive correlation between X_1 and X_2, the resulting dispersions in a two-dimensional plot would appear as back in *Figure 2.2*. Examination of these group configurations should convince the reader that X_2 contains information relevant to membership in the scientist group even though mean differences on X_2 are not found. For example, whether or not an individual with a score x_1 on X_1 is in the scientist group will depend partly upon his X_2 score. If it is low, he is more likely to be in the scientist group.

A related difficulty is that there is no provision for random aspects of the process. For a long time scientists refused to admit the possibility of a "dice throwing God", but now great progress is being made in many scientific disciplines by introducing models which can allow random variables. It is probably necessary to admit the possibility of "fortunate accidents" in becoming a scientist, and provide for that possibility in our model of the process.

Finally, such hypothesis do not assist prediction of individual career choices. Although they seem parsimonious in that they are attempts at summarizing a large amount of information,the hypothesis does not appear to be in a form which facilitates prediction, and it is prediction which inspires confidence.

This final section of Chapter 2 has attempted to show some possible weaknesses in the deductive approach which has proved so successful in science. The McClelland example was chosen because it seemed the best illustration available of the classical technique of attempting to explain a set of independent observations by being able to deduce them from a single explanation of why boys become scientists.

This discussion was included here as a partial support of the multivariate-inductive approach used in the Scientific Careers Study. Here we are not testing a specific hypothesis of why boys become scientists. Rather, we are attempting to provide a better description of the group of boys within which the future scientists lie, a description which preserves the combinations of attributes that occur within individuals.

CHAPTER 3
THE HIGH SCHOOL TO COLLEGE TRANSITION

A critical five-year period in the career development of scientists occurs during the last two years in high school, the transition to college, and the first three years in college. This chapter examines the career development process during these five years.

The subjects selected for study were eleventh grade high school boys, all taking the college preparatory curriculum. Almost all of our future scientists and engineers lie within this group. Today it is essentially impossible to become a scientist unless you go to college, and the college preparatory curriculum is essentially a prerequisite for college attendance.[1]

THE SELECTION OF RELEVANT CRITERIA

In Chapter 2 it was argued that previous investigators were frequently too arbitrary in the manner in which the criterion groups were determined. That discussion places this investigator in the difficult position of having to arrive at a more rational procedure. This was attempted by means of two primary considerations:

(A) What types of information related to the career development of scientists are contained in the kinds of measurements we are able to make, measures of both the individual's behavior and his environment?

(B) What are the major types of career decisions with which this investigation is concerned?

A consideration of these two questions led to the following tentative hypotheses:

1. Measure of interest and temperament primarily contain information regarding the science-technology orientation of the student, whether or not he goes to college.

2. Measures of abilities are related to school decisions, (e.g., college or not) and to specific decisions within school (e.g., science or not).

3. Measures of environmental variables (e.g., family background data) are primarily related to college or not.

In view of these preliminary hypotheses, the use of a two group criterion, where one group is the potential scientists pool (PSP)[2] and the other is the non-science group (NS), would result in two types of confusions. On the personality measures, the PSP would overlap those members of the NS who were science-technology oriented, but who were not going on to college and are thus not in the PSP. Measures of aptitude, achievement, and environment on the other hand, would confuse members of the PSP with those in the NSG who were college bound.

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[1] Details and rationale of sample selection are found in Chapters 1 and 2.

[2] Going to college, majoring in one of the natural sciences, mathematics, or engineering.

At first it was deemed desirable to use three different two-group criteria: (1) PSP vs. NS, (2) science-technology oriented, regardless of college attendance (ST) vs. non-science-technology oriented (NST); (3) College vs. non-college. The criterion to be used would depend upon the system of predictors to be examined. The problem with this approach is that this would not be a test of our hypotheses, but rather an acceptance of them. If, for example, interest measures were only used with the ST vs. NST criterion, it would not be a test of whether or not the interest measures also contained information relative to college going.

Therefore, a four-group criterion seemed to be the most reasonable approach: (1) college-science (PSP), (2) college-nonscience (CNS), (3) noncollege-technology (NCT) and (4) noncollege-nontechnology (NCNT). Group membership was determined at each of the five years of this study by interviews and follow-up questionnaires. The predictor variables were measured in eleventh grade, unless otherwise specified.

The classification into the four criterion groups was done in the following way: A summary sheet was prepared for each student, summarizing his career goals, and the educational plans and decisions he made during the five years of the study. An illustrative summary sheet is presented in Appendix A4. To classify an individual into one of the four groups used here, his goals and school situation were considered, and his sheet was placed into one of four piles. After each pile was checked for possible classification error, the resulting four groups served as the basis for these analyses. This was done for each of the five years.

The primary definitions of the four groups, together with five selected cases to illustrate the variety of goals within each group, are as follows: [1]

(1) Potential Scientist Pool (PSP): attend a four year college, major in one of the natural sciences or engineering with plans to pursue a career in science, applied science, or engineering.

- a. Physics major, wants research in physics.
- b. Math major, wants college teaching.
- c. Electrical engineering major, wants same.
- d. Physics major, wants research in meteorology.
- e. Mechanical engineering major, wants aero-space engineering.

(2) College-Nonscience (CNS): attend a four year college, majoring in something other than science or engineering, with no plans to pursue a career in a scientific field.

- a. Business administration major, wants same.
- b. Economics major, wants law.
- c. Philosophy major, wants newspaper columnist.
- d. History major, wants teaching.
- e. Sociology major, wants urban renewal work.

(3) NonCollege-Technical (NCT): Not attend a four year college. Full or part-time school attendance may be the case, but only at a one or two year technical school. The career is in technology

---

[1] Special rules were needed for groups (1) and (2): Three types of goals presented a little classification difficulty-doctors, dentists, and architects. Some boys seem headed toward medicine because of an interest in science, others because of an interest in people. Some want to become architects because of its engineering-drafting component, others because of the artistic, aesthetic appeal. In most cases, their detailed statements about this goal clarified this for us, and they were classified either into group 1 or 2 accordingly. Since their total number is small, the effect of this decision is small until individual cases are considered, as will be seen later in this chapter. In case the reader feels we are hedging here, it should be emphasized that the basis for this decision was information found in the criteria (descriptions of career plans), not in predictors.

at least for the near future.

a. Plumbers apprentice.
b. Electronic technician.
c. Was chemistry major, now working in plastics firm.
d. In Navy as a technician.
e. Driller in construction company.

(4) NonCollege-NonTechnical (NCNT): Not attend a four year college. Full or part-time school attendance may be the case, but only at a junior college or two year business or accounting school. The career is not in technology.

a. Bank teller.
b. Traffic management in motor transport.
c. Accountant.
d. Policeman's school.
e. Purchasing office worker.

MIGRATIONS AMONG CRITERION GROUPS FROM HIGH SCHOOL TO COLLEGE

One of the questions for which this investigation sought an answer is whether or not tests administered at time one (T_1) could predict educational decisions and career plans at T_2 better than you could by simply asking the student at T_1 what his future plans are. Several approaches to answering this question are considered in this report.

First of all, the changes from T_1 plans which occurred should be considered. These plans were determined in eleventh grade interviews. Table 3.1 compares 11 self-predictions (stated plans at eleventh grade) with classification at grades 12, 13, 14 and 15. At each of these grades the classifications were based upon that year's current plans and decisions. If actual decisions were obviously inconsistent with plans, the decisions had priority. First of all, notice that over one-half of all of the changes which were made over the five year period involved movement out of the Potential Scientist Pool. Of the 91 boys (47% of sample) in the PSP at eleventh grade, 34 moved out the following year. Seventeen moved in, leaving a net loss of seventeen. Only 62 per cent of the boys had the same career plans in grade 12 as they did in grade 11. Actually more than this had changed specific plans, but only 38 per cent involved changes in group classification.

At two years after high school, only 38 of the original 91 boys were still in the PSP. Ten had previously come from other groups, bringing the total to 48 (25% of our original sample). It should be noted, however, that these ten migrations were among the 17 boys who had moved into the PSP at grade 12; they are not new migrations at grade 14.

By making a very rigid set of classification rules, and by use of our summary sheet sorting procedures, reliability of classification was nearly perfect. At this stage of development it was not considered necessary to distinguish between "pure" and "applied" science. The students themselves do not make this distinction, nor do they have to.

One difficulty with Table 3.1 is that you cannot determine whether or not the same boys are in a particular cell from year to year. To get a better idea of career plan patterns, Table 3.2 was constructed. The Table would have been unnecessarily complicated if membership in all four groups had been preserved, so a simple binary coding scheme was used, 1 = PSP and 0 = one of the three non-PSP groups.

TABLE 3.1

ELEVENTH GRADE SELF-PREDICTIONS

		Grade 11 Self-Prediction[1]					
		PSP	CNS	NCT	NCNT		
Grade 12 Classification	PSP	57	11	6	0	74	62% hits
	CNS	15	32	5	2	54	
	NCT	16	2	17	3	38	
	NCNT	3	7	2	14	26	
		91	52	30	19	192	
Grade 13 Classification	PSP	46	10	5	0	61	57% hits
	CNS	19	31	4	1	55	
	NCT	21	3	19	5	48	
	NCNT	5	8	2	13	28	
		91	52	30	19	192	
Grade 14 Classification	PSP	38	7	3	0	48	50% hits
	CNS	26	26	2	4	58	
	NCT	23	9	22	6	60	
	NCNT	4	10	3	9	26	
		91	52	30	19	192	
Grade 15 Classification	PSP	28	7	2	0	37	48% hits
	CNS	33	32	3	4	72	
	NCT	21	6	22	4	53	
	NCNT	9	7	3	11	30	
		91	52	30	19	192	

TABLE 3.2

PSP MEMBERSHIP OVER THE FIVE YEARS[2]

	Grade					No. of Students	Per Cent
	11	12	13	14	15		
Always in PSP	1	1	1	1	1	24	12.5
Left PSP in Grade 15	1	1	1	1	0	9	4.5
" " " " 14	1	1	1	0	0	10	5
" " " " 13	1	1	0	0	0	13	7
" " " " 12	1	0	0	0	0	28	14.5
Entered PSP in Grade 12	0	1	1	1	1	5	3
" " " " 13	0	0	1	1	1	1	.5
Never in PSP	0	0	0	0	0	81	42
Ended in PSP with various patterns of 0's and 1's						6	3
Ended out of PSP with various patterns of 0's and 1's						15	8
					TOTAL	192	100%

---

[1] The number of "hits" is underlined.

[2] Coded: 1=PSP; 0=either CNS, NCT, or NCNT.

The first line of the table shows that twenty-four boys (about 12%) stayed in the PSP all five years. The next four lines indicate that the largest movement out of the PSP occured between grades 11 and 12 (28 boys), with the following years leveling off at about ten émigrés each year.

Movement into the PSP was almost non-existent. Only five moved in and stayed there after grade 11, with only one boy doing this after high school graduation. There were six boys with random patterns who were in the PSP at grade 15. All six of them had been in the PSP at either grade 11 or 12. Fifteen others moved back and forth, and at grade 15 were not in the PSP. The eighty-one boys who never considered goals in science or engineering account for the largest single pattern (42%).

Discriminant Analysis Using College and Science Plans As Criteria

This section of Chapter 3 reports a series of four-group discriminant analyses. The task here is to examine the ways in which the four criterion groups, based upon membership two years after high school graduation, differ on information collected four years earlier. A brief summary of the results of these analyses is followed by detailed discussions of each analysis. This takes the reader up to the section entitled "Comparisons of the Predictor Systems."

SUMMARY OF FOUR-GROUP DISCRIMINANT ANALYSES

Abilities: Only a single discriminant function is needed to describe the ability differences among these four groups. The PSP is much more able than the other three groups. The students who go on to college to major in a field other than science (CNS group) are no more able than the college preparatory students who do not go on to college (NCT and NCNT groups).

Interests: Two functions are needed to describe the differences among these four groups on expressed interest. The major function distinguishes the two science-technology groups (PSP and NCT) from the others (CNS and NCNT). A second interest function separates college from non-college. The two science-technology groups continue to resemble each other closely on the major function even after the PSP had completed two years of college.

Temperament: Two functions are needed here also, except that college vs. non-college is the primary discrimination, with the science-technology vs. the rest a secondary discrimination.

Work Values: An inventory of aspects of work which people feel are important primarily distinguishes the two college groups from the two non-college groups.

Teacher Ratings: Although the two science-technology groups behaved similarly on expressed interest, the science teacher's ratings of manifest interest did distinguish the PSP from the NCT group.

High School Courses: Although all students were taking the college preparatory curriculum, the specific pattern of courses was still a useful discriminator. Major trends were that the two college groups took more work in foreign language and the two science-technology groups took more mathematics. There were no differences among the four groups in the amount of non-academic subjects elected.

TABLE 3.3
SCHOLASTIC ABILITY DISCRIMINANT ANALYSIS

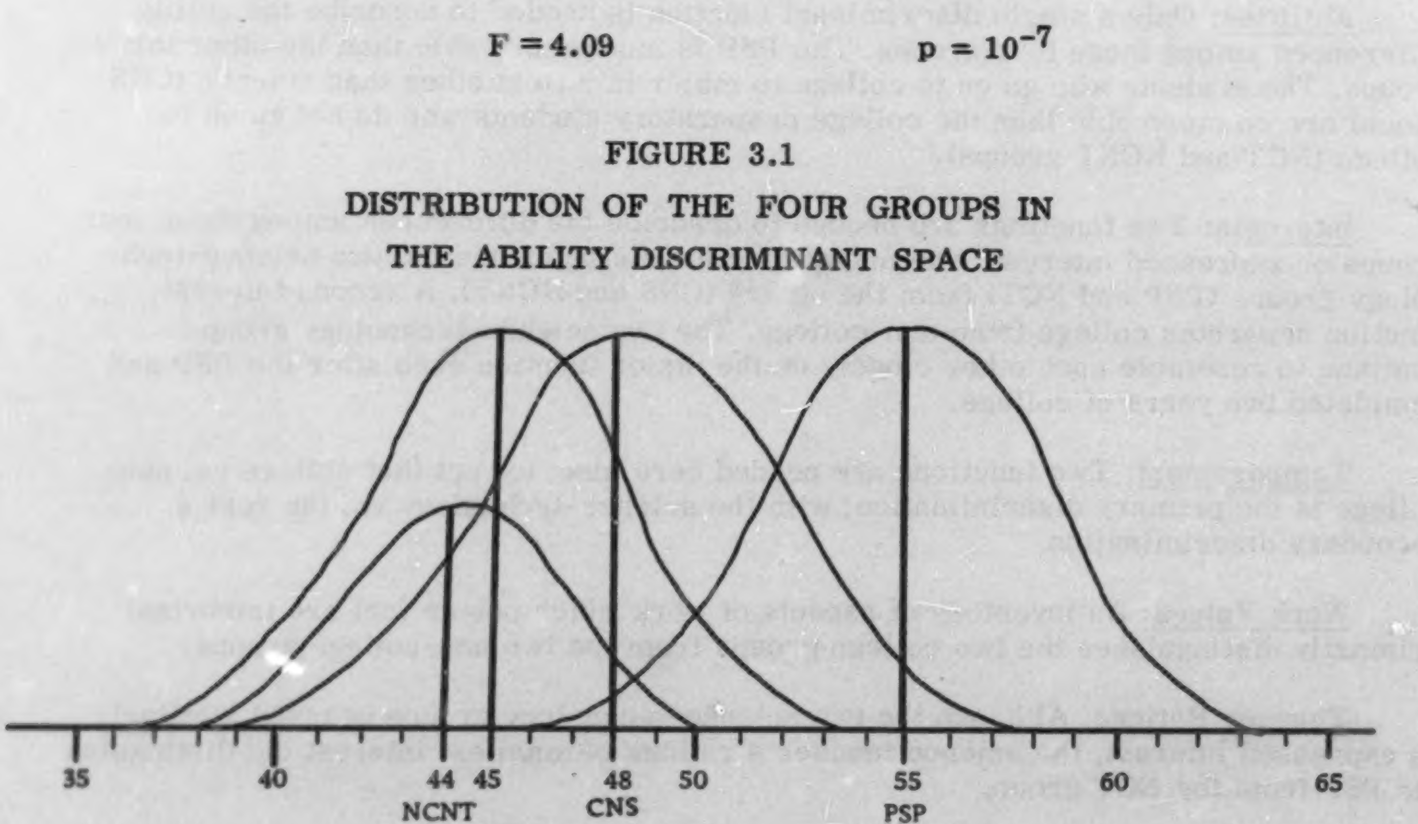
		Group Means				Four Group	Two-Group Comparisons	
		PSP	CNS	NCT	NCNT	F^3_{186}	CNC F^1_{188}	PSP-NS F^1_{188}
1.	STEP Math	18.08	14.39	13.75	13.00	13.96	17.21	39.61
2.	STEP Science	20.83	18.65	18.73	17.54	5.15	5.04	13.54
3.	Spatial	24.42	23.72	23.17	23.50	---	1.35	1.64
4.	Logical	23.65	22.16	22.37	22.62	2.96	---	8.42
5.	Numerical	17.31	15.49	14.46	14.77	5.33	9.79	13.82
6.	Verbal	22.77	21.09	19.25	18.42	5.15	12.55	9.97
7.	Class Rank	59.71	53.16	47.98	48.77	22.64	45.11	50.68

Scaled Vector		Latent Roots		% of Discriminating Variance
1.	38	1)	.462	88%
2.	9	2)	.043	8%
3.	-2	3)	.019	4%
4.	11			
5.	-7	Wilks' lambda = .644		$ndf_1 = 21$
6.	-5			$ndf_2 = 517$
7.	64			

F = 4.09 $p = 10^{-7}$

FIGURE 3.1

DISTRIBUTION OF THE FOUR GROUPS IN THE ABILITY DISCRIMINANT SPACE



The Rorschach: The Rorschach test appears to have little if any relationship to membership in these four groups.

Environment: Of the environmental variables considered in this investigation, only measures of socio-economic status (SES) were found to be relevant. These were simply related to college going or not. Although ability distinguished the college science students from the non-college groups but found college non-science no more able than the non-college groups, SES distinguished both college groups from the students who did not go on to college. The PSP is a more able group than one would expect from their SES. The primary difference between boys who go on to college as non-science majors and those who do not go on to college is family SES.

DETAILS OF THE FOUR-GROUP DISCRIMINANT ANALYSES

SCHOLASTIC ABILITIES

The most obvious set of variables to examine first are those which measure aptitude and achievement. The seven used here are: 1) STEP Mathematics, 2) STEP Science, 3) CMM Spatial, 4) CMM Logical, 5) CMM Numerical, 6) CMM Verbal, and 7) high school class rank.[1]

The four- group discriminant analysis, reported in Tables 3.3 and 3.4, produced very significant group differences on aptitude and achievement, as would be expected with college or not as part of the criterion. However, a few unexpected trends are revealed here. First of all, a single discriminant function, of a possible three, preserves most (88%) of the differences among the four groups found in these seven measures of aptitude and achievement. The scaled vector reflects the fact that the primary differences here are found in class rank and STEP mathematics, both having high loadings, thus each contributing unique information regarding group differences in spite of an intercorrelation of .44. The four CMM aptitude measures and STEP science tell us very little about the differences among the four groups that is not found in these two achievement measures.

The F ratios in the three right hand columns of Table 3.3 indicate the relative separation which is produced by each of the measures, using the four group criterion; and two two-group criteria—College (C) vs. Non-College (NC) and college-science (PSP) vs. the rest (NS). Notice that except for verbal aptitude, the PSP vs. NS differences are greater than the C vs. NC. This indicates that the non-science college students look more like the non-college students than the college-science group.

A three group discriminant analysis was conducted leaving out the PSP. This revealed that the CNS group probably comes from the same multivariate population as do the two non-college groups, in so far as the abilities measured here are concerned. A Wilks' lambda of 0.88 results in an F ratio of 1.25, and with 14 and 266 degrees of freedom, this is not significant at the .10 level. Ability certainly does not seem to be a determinant of college going for the non-science group, at least when compared to other "college-prep" students who do not end up in college.

The top of Table 3.4 reports the "hits and misses" for these data. Rows of this table define group membership based upon follow-up information, and columns define the group classification based upon information in the predictor variables, eleventh grade abilities in this case. This predictor probability classification scheme was briefly outlined in Chapter 2. It should be pointed out that these are not true predictions, but rather are group separations. This is because the probabilities for group membership were determined for the same students upon which the prediction equations are based.

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[1] See Appendix A for complete description of all instruments and scales used in this investigation. CMM is the California Test of Mental Maturity.

TABLE 3.4

SCHOLASTIC ABILITY DISCRIMINATIONS

		Predictor Classifications				Number in Criterion Group
		PSP	CNS	NCT	NCNT	
Grade 14 Group Membership	PSP	34	12	2	0	48
	CNS	15	11	31	0	57
	NCT	6	15	38	0	59
	NCNT	3	5	18	0	26
		58	43	89	0	190

44% hits

Probabilities for Group Centroids

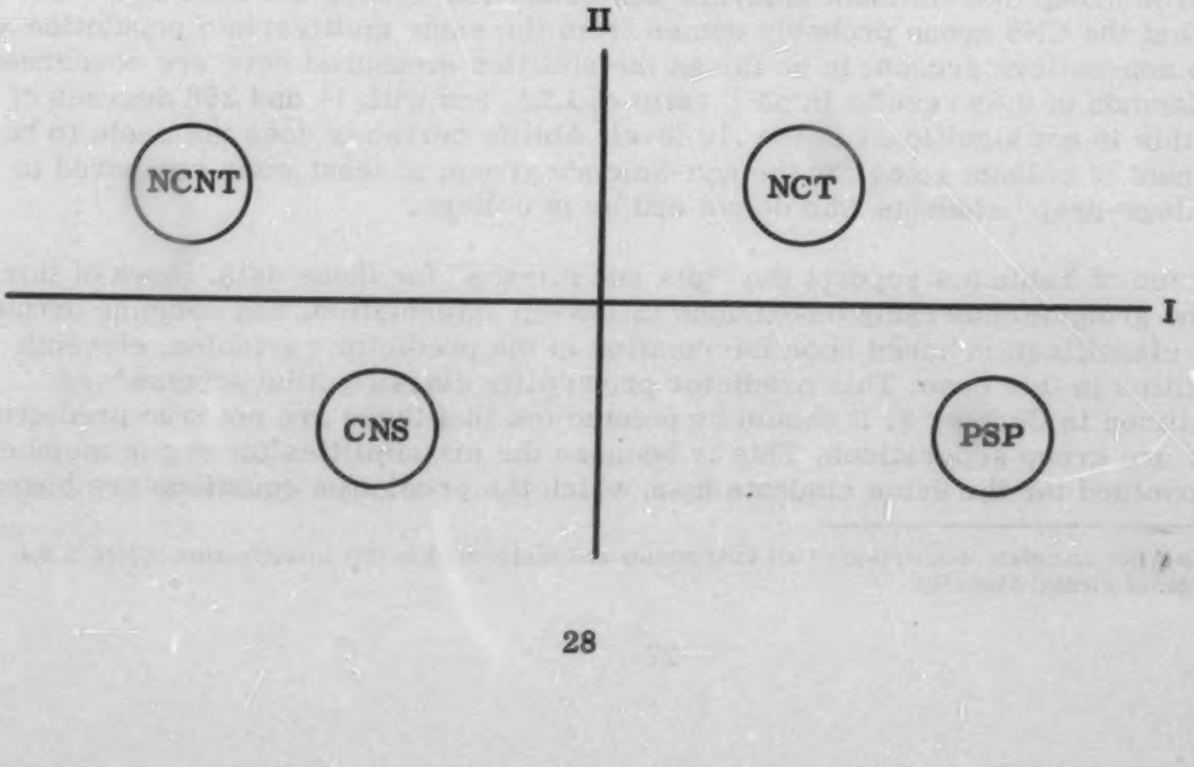
	PSP	CNS	NCT	NCNT	Row Total
PSP	.52	.28	.14	.06	1.00
CNS	.16	.35	.34	.15	1.00
NCT	.06	.34	.41	.19	1.00
NCNT	.06	.33	.42	.19	1.00

Discriminant Space

	Centroids	Variances
PSP	55	28
CNS	48	45
NCT	45	40
NCNT	44	37

FIGURE 3.2

RELATIVE POSITIONS OF GROUP CENTROIDS IN INTEREST DISCRIMINANT SPACE



However, the amount of separation produced is a useful index since it is probably the upper limit of the extent to which true predictions are possible using these predictors from populations represented here.

Since this is the first presentation of this type of table, further discussion may be useful for clarification. For example, six students who were non-college-technical two years after high school were classified as PSP on the basis of ability. The fact that there were only 83 hits (sum of 34 + 11 + 38 + 0) out of 190 (44%) is primarily due to the confusions among the three NSG groups. Thirty-four of the 48 PSP (71%) were correctly classified on the basis of this aptitude-achievement information alone. In the PSP-NSG two-group ability discriminant analysis, 83% hits were obtained (see Table 3.3).

The middle section of Table 3.4 reports the group densities at the group centroids. For example, of the students having the same pattern of ability scores as the means of the PSP group, about 52% are actually in the PSP at grade 14, 28% are CNS, 14% are NCT, and 6% are in the NCNT group. Perhaps Figure 3.1 will help the reader to understand this table and the several like it which follow.

Figure 3.1 illustrates the nature of the group separations in the ability discriminant space. The means (centroids) and dispersions of the groups in this discriminant space are found in the bottom of Table 3.4. Again, the PSP difference from the other three groups can be readily seen. Notice also that the NCNT distribution is completely "covered" at all points along this discriminant axis. A group density, which is the height of the curve in Figure 3.1, at any given point when compared to other group densities, determines the probability of group membership at that point. No individuals were assigned to the NCNT group in the top of Table 3.4 because the density for some other group is always greater. For example, a student with a discriminant score of 40 would be assigned to the NCT group, since most students with the aptitude-achievement pattern resulting in a discriminant score of 40 are in the NCT group, as seen by the heights of the three curves at that point. Again, going back to the Probabilities for Group Centroids, Table 3.4, the fact that the densities of the NCT and CNS groups are greater at the NCNT mean that is the density for the NCNT group is seen in both the table and the figure.

To explore the possibility that information was lost by not taking into account the technical school or junior college attendance of the two non-college groups, a two group discriminant analysis was performed: Technical or Junior College vs. Non-College. The results indicate that there are no apparent ability differences between these two groups.

INTERESTS

Using patterns of Kuder interest scores at eleventh grade as the predictor system, two discriminant functions appear to be necessary for describing the differences among the four groups (Table 3.5). The major difference here is the separation of the science-technology oriented groups (PSP and NCT) from the other two groups (CNS and NCNT). The scaled vectors allow comparisons of the contributions which variables make to the discriminant functions. On the first function the useful variables, with PSP and NCT the low groups, are scientific (negatively loaded) and the clerical, social service and persuasive scales (positively loaded). The second discriminant function utilized patterns of interest for which the two college groups (PSP and CNS) differed from the two non-college groups (NCT and NCNT). Inspecting the scaled vector II, one sees that mechanical, scientific, artistic and social service were the useful variables. The scientific scale is useful to "suppress" the effect of the mechanical interest of the PSP. Inspection of the patterns of means, the scaled vectors, and centroids (bottom Table 3.6) should clarify this point.

The top two tables of Table 3.6 also illustrate the similarity of the PSP and NCT groups. Almost as many of the PSP are classified NCT (18) as they are PSP (22). In the table of probabilities we find high proportions of PSP and NCT at each others' centroid, the same being true of the CNS and NCNT groups. In spite of the overlap, a fair degree of separation is accomplished (50% hits) with this interest information alone. It should also be pointed out that this is no better than self-predictions, as was seen in Table 3.1.

Since this is the first discriminant analysis in this chapter which reports two functions, Figure 3.2 is presented to show the relative positions of the centroids in this two dimensional space. Notice that function I separated the science-technology groups (PSP and NCT) from the other two, whereas function II separates college from non-college. Again, to get some sense of the overlap in this space, examine the middle section of Table 3.6. For example, of those students having a pattern of scores which locates them at the point at which the PSP centroid is located, you would expect 44% of them to be in the PSP, 18% in CNS, 34% in NCT, and 4% in NCNT. Of course, this is not found by actually counting those students who may lie at this point, but rather by a comparison of the densities of the four group distributions at that point. The densities are determined from the population estimates of the means and dispersions (variance-covariance matrix) obtained from each of the samples.

TABLE 3.5

KUDER DISCRIMINANT ANALYSIS

	Group Means					Scaled Vectors	
	PSP	CNS	NCT	NCNT	F^{3}_{186}	I	II
1. Outdoor	46.10	42.67	48.53	43.81	2.19	52	18
2. Mechanical	43.15	38.19	48.00	41.38	7.29	9	93
3. Computational	32.40	31.07	30.37	29.58	---	7	13
4. Scientific	52.56	45.12	48.61	38.50	16.23	-51	-47
5. Persuasive	33.04	43.21	35.90	44.35	10.16	66	-5
6. Artistic	20.94	19.44	24.47	25.00	5.04	30	74
7. Literary	19.29	19.86	16.97	19.69	1.38	27	10
8. Music	11.65	10.42	9.98	12.15	----	11	-3
9. Social Service	39.29	43.56	37.81	35.50	2.88	52	-24
10. Clerical	43.87	49.11	44.31	52.73	4.89	89	-6

Latent Roots	% of Discriminating Variance
1) .412	70%
2) .152	26%
3) .028	4%

Wilks' lambda = .598 $\quad$ $ndf_1 = 30$

$ndf_2 = 520$

F = 3.32 $\quad$ $p = 10^{-7}$

TEMPERAMENT

The four groups differ on only two of the ten temperament variables as measured by the Guilford-Zimmerman Temperament Survey (Table 3.7). On the restraint-seriousness scale, the major separation is college vs. non-college, with the two science-technology groups being furthest apart. The other useful variable, thoughtful-reflective, separates the two college groups, with the PSP being on the high end of this scale, CNS on the low end. Thus two different types of separation occur in these data, and two discriminant functions result. Since there are only two significant variables, the weights in the two sclaed vectors representing the first two discriminant functions reflect correlations with these two significant variables as well as mean differences.

Because there are only two really useful predictors among the ten temperament scales, the separation of the four groups is not particularly good (Table 3.8). Notice, for example, that the probability scheme assigns no students to the NCNT group. There appears to be no point in the discriminant space at which the NCNT group density is higher than the density of the other three groups. This was not the case in the Kuder interest space.

TABLE 3.6

KUDER INTEREST DISCRIMINATIONS

		Predictor Classifications				Number in Criterion Group
		PSP	CNS	NCT	NCNT	
Grade 14 Group Membership	PSP	22	8	18	0	48
	CNS	7	32	12	6	57
	NCT	15	10	33	1	59
	NCNT	3	6	8	9	26
		47	56	71	16	190

50% hits

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT	Row Total
PSP	.44	.18	.34	.04	1.00
CNS	.16	.50	.25	.09	1.00
NCT	.28	.20	.44	.08	1.00
NCNT	.05	.42	.28	.25	1.00

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	57	20	45	115
CNS	67	18	58	125
NCT	61	27	66	103
NCNT	72	27	119	106

SVIB INTEREST AND AVL VALUES

The Strong Vocational Interest Blank (SVIB) and the Allport-Vernon-Lindsey (AVL) Study of Values were administered to this group of boys two years after high school, at the same time that the information for the 11:14 group classifications was obtained. Although attributes and group membership were obtained at the same time, it seemed of interest to know the manner in which the four groups differed on these two instruments. This information could then be related to trends obtained for the college groups.

These discriminant results are very similar to those obtained from the Kuder interest test, administered in eleventh grade. Two functions are obtained, the major one separating the PSP and NCT groups from the non-science, non-technology groups (see the centroids, Table 3.10). The second function separates the two college groups (PSP and CNS) from the two non-college groups. An interesting point here is that the NCT group still looks like the PSP on the primary interest function, as it did on the Kuder data four years earlier.

One point of special interest here is the way in which apparently irrelevant scales are useful in discriminating among these groups. This is one reason why it may make sense to talk about this type of test as a personality test, one which measures more than a positive career interest. It is the whole pattern of likes and dislikes, or relative likes and dislikes, which determine group membership here, as can be seen by inspecting the scaled vectors, the group means, and the centroids.

TABLE 3.7

GZ TEMPERAMENT DISCRIMINANT ANALYSIS

	Group Means					Scaled Vectors	
	PSP	CNS	NCT	NCNT	F^{3}_{186}	I	II
1. Gen. Activities	16.31	16.81	17.03	17.81	----	-14	10
2. Restraint, Serious	16.92	15.51	12.93	14.23	6.37	47	29
3. Ascendance	16.02	15.02	15.08	14.81	----	14	-22
4. Social Interest	17.69	18.77	18.39	17.96	----	1	30
5. Emotional Stabil.	16.98	16.72	17.44	14.42	1.99	-15	-18
6. Objectivity	16.17	15.65	15.49	13.54	1.49	28	-4
7. Friendliness	12.23	11.89	11.97	10.92	----	-14	-10
8. Thoughtful, Reflective	19.23	15.77	16.47	17.46	4.23	-3	-48
9. Pers. Relations	15.73	15.89	16.47	15.96	----	-16	-2
10. Masculinity	19.67	20.16	21.19	20.35	1.44	-17	-6
N =	48	57	59	26			

Latent Roots	% Discriminating Variance
1) .1622	54%
2) .0918	31%
3) .0450	15%

Wilks' lambda = .754 $ndf_1 = 30$

$ndf_2 = 520$

F = 1.75 p = .009

WORK VALUES

The Work Values Questionnaire also contained information which is significantly related to membership in these four groups. Here, two discriminant functions resulted. On the first functions, the values "invent", "theorize," and "be well known" have the highest loadings, separating the PSP and NCNT groups the farthest, with CNS and NCT clustering in between (see Centroid I Table 3.12). The second functions separates CNS from NCT, but seems to be utilizing several minor, uninterpretable trends. Little confidence can be placed in this second function. The predictor tables in Table 3.12 reflect the general overlap observed in the centroids on variances in this discriminant space.

Although there appears to be a better hit-rate here than with the Kuder, this is probably due to the fact that more parameters are being fitted; that is, more predictors are present in the Work Values questionnaire. This illustrates the fact that good separation can be achieved by simply having a large number of predictors; and if the equations are not based on highly significant group differences, cross-validation results for the predictor equation are poor.

What can be concluded from the data is that the PSP place a higher value on ideas and recognition than on variety and power. Although interests for the two science-technology groups are similar, their work values appear to be different.

TABLE 3.8

GZ TEMPERAMENT DISCRIMINATIONS

		Predictor Classifications				Number in Criterion Group
		PSP	CNS	NCT	NCNT	
Grade 14 Group Membership	PSP	22	15	11	0	48
	CNS	9	36	12	0	57
	NCT	8	21	30	0	59
	NCNT	3	13	10	0	26
		42	85	63	0	190

45% hits

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT	Row Sum
PSP	.32	.33	.22	.13	1.00
CNS	.20	.41	.22	.17	1.00
NCT	.19	.28	.34	.19	1.00
NCNT	.19	.35	.28	.18	1.00

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	.79	-11	18	12
CNS	-.61	-8	13	10
NCT	-3.21	-11	15	16
NCNT	-2.06	-10	15	9

TEACHER RATINGS

The high school science teachers were asked to describe the extra-class science activities of their boys, in so far as they were familiar with them. Two variables which seemed useful are: (1) the extra time which students spent in their science classroom, at lunch hour or after school, engaged in science-type activities; and (2) whether or not the student engaged in individual research projects. Both variables produced highly significant differences, with the PSP being different from all three groups (Table 3.13). It is interesting to note that although the PSP and NCT groups behave similarly on expressed interests (Kuder), the NCT group clusters with the two non-science groups when manifest science interest, as observed by science teachers, is the predictor system.

TABLE 3.9

SVIB AND AVL DISCRIMINANT ANALYSIS

	Group Means					Scaled Vectors	
	PSP	CNS	NCT	NCNT	F^{3}_{151}	I	II
1. Professional	41.62	31.87	37.03	32.33	7.32	-14	-9
2. Technical	44.47	27.79	44.26	28.95	27.05	51	-31
3. Prod. Mgr.	35.32	30.87	38.77	30.33	6.53	44	-27
4. Active	41.36	32.85	46.06	36.90	9.71	3	49
5. Welfare	34.79	39.13	29.20	37.48	6.53	-19	-7
6. Music	38.06	30.31	28.80	35.81	5.63	-17	-15
7. CPA	25.51	28.62	19.00	23.14	6.03	-14	-29
8. Bus. Detail	25.74	34.67	27.94	33.71	5.36	-31	-3
9. Bus. Contact	29.09	38.98	29.91	33.67	10.21	21	-37
10. Verbal	35.64	35.90	31.94	35.24	1.86	3	22
11. Pres. Mfg.	25.21	28.44	29.94	25.90	2.09	-22	63
12. Theoretical	48.79	42.58	48.29	42.90	11.45	24	9
13. Economics	39.98	44.54	44.97	45.24	4.49	-50	35
14. Aesthetic	35.23	31.31	31.11	34.33	2.98	-7	2
15. Social	33.94	35.96	35.03	37.29	1.57	-24	27
16. Political	42.60	46.12	42.49	42.24	3.83	-18	-6

Latent Roots	% of Discriminating Variance
1) .892	63%
2) .364	26%
3) .154	11%

Wilks' lambda = .332 $ndf_1 = 51$

$ndf_2 = 403$

F = 3.54 $p = 10^{-12}$

The teachers were also asked to predict which of their students participating in this study would successfully complete their college preparation and become scientists. As of two years after high school, their 74% hit rate is found in Table 3.14. Of the 48 students in the PSP at grade 14, seventeen were not considered future scientists, and thirty-three boys who did not go on in science were predicted to do so by the teachers. Still a 74% hit rate is good, even for a two group criterion.

HIGH SCHOOL COURSES

In an effort to determine whether or not the pattern of courses selected in high school could predict membership in our four criterion groups, six variables based upon the high school transcript were used (Table 3.15 and 3.16). Three variables were significantly related: number of semesters of mathematics taken; whether or not physics was taken (1 = yes, 0 = no); and number of semesters of foreign languages elected.

Since the science course variables 2, 3, and 4 were coded in a binary fashion, the means in table 3.15 represent the proportions taking each of the science courses. Thus, for example, 15% of the PSP did not take physics, and only 2% of the PSP did not take chemistry. The four groups did not differ in the extent to which biology was taken. The non-college technical (NCT) group took physics as frequently as the college non-science (CNS) group, but this was not true of chemistry. Chemistry was the most frequently elected science across all groups.

TABLE 3.10

SVIB - AVL (INTEREST & VALUES) DISCRIMINATIONS

		Predictor Classifications				Number in Criterion Group
		PSP	CNS	NCT	NCNT	
Grade 14 Group Membership	PSP	34	7	6	0	47
	CNS	6	39	5	2	52
	NCT	9	5	21	0	35
	NCNT	4	10	2	5	21
		53	61	34	7	155

64% hits

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT	Row Total
PSP	.66	.13	.15	.06	1.00
CNS	.08	.68	.03	.21	1.00
NCT	.22	.07	.67	.05	1.00
NCNT	.05	.59	.06	.30	1.00

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	-18.4	22.6	52.7	24.8
CNS	-31.8	24.9	53.9	23.9
NCT	-18.1	29.9	38.8	18.1
NCNT	-31.6	28.1	67.0	21.7

TABLE 3.11
WORK VALUES DISCRIMINANT ANALISIS

	Group Means						Scaled Vectors	
	PSP	CNS	NCT	NCNT	F^{3}_{170}	F^{1}_{172}	I	II
1. Invent	7.22	6.18	6.27	4.96	6.95	12.46	14	-3
2. Create A	2.93	2.88	3.35	3.91	1.69	---	-9	-8
3. Organize	5.64	6.27	5.55	6.09	1.67	---	-5	7
4. Theorize	6.11	4.61	4.75	3.83	7.13	18.16	12	-7
5. Variety	6.38	6.78	7.13	7.57	2.31	4.25	-7	-2
6. Autonomy	6.47	6.49	6.07	5.78	1.24	---	5	3
7. Clean, quiet, indoors	4.20	4.55	4.55	4.52	---	---	-1	1
8. Directions from others	2.51	2.53	2.87	2.57	---	---	4	-0
9. Friendly colleague	6.24	6.90	7.05	6.78	2.08	5.82	-2	5
10. Free personal life	6.73	6.65	7.20	6.87	1.01	---	0	-9
11. Help others	6.04	6.63	6.22	5.43	2.08	---	4	8
12. Secure	6.82	6.96	7.67	6.91	2.37	1.90	0	-8
13. Money	5.91	5.39	6.09	5.70	1.15	---	1	-9
14. Well-known	4.53	4.49	3.44	3.04	4.13	3.53	10	7
15. Power over others	3.62	4.49	3.45	3.70	2.30	---	-6	10
N	45	51	55	23				

Latent Roots	% of Discriminating Variance
1) .369	60%
2) .190	31%
3) .060	9%

Wilks' lambda = .579 $ndf_1 = 45$

$ndf_2 = 464$

F = 2.09 $p = 10^{-4}$

As far as mathematics is concerned, the NCT group took as much as did the CNS group, with the NCNT group taking the least. On the otherhand in foreign languages, the NCT group took the least, this variable splitting more along the lines of college or not. There are no significant differences among the groups as far as the frequency with which non-academic subjects (shop, typing, etc.) were taken. It should be recalled, however, that the entire sample was in the college preparatory curriculum when selected for this study at eleventh grade.

Two discriminant functions were found useful here. The major one is primarily a college vs. non-college discrimination, as can be seen by inspecting the centroids at the bottom of Table 3.16. The second function separated the two science-technology groups from the CNS and NCNT groups. Again the scaled vectors tell us how the variables were combined to achieve this separation, foreign languages being the primary variable on the first function and mathematics on the second function.

TABLE 3.12

WORK VALUES DISCRIMINATIONS

		Predictor Classifications				Number in Criterion Group
		PSP	CNS	NCT	NCNT	
Grade 14 Group Membership	PSP	23	9	12	1	45
	CNS	6	28	12	5	51
	NCT	10	10	33	2	55
	NCNT	2	5	8	8	23
		41	52	65	16	174

53% hits

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT	Row Total
PSP	.41	.24	.31	.04	1.00
CNS	.20	.43	.31	.06	1.00
NCT	.21	.23	.46	.10	1.00
NCNT	.11	.26	.36	.27	1.00

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	6.1	-2.6	4.5	2.9
CNS	4.5	-1.2	3.4	3.4
NCT	4.3	-3.1	2.7	3.5
NCNT	2.3	-2.6	5.1	2.9

TABLE 3.13

TEACHER RATING DISCRIMINATIONS

	Group Means				
	PSP	CNS	NCT	NCNT	F
*1. Extra Science Class Time	2.67	3.25	3.47	3.43	9.72
**2. Individual Research	1.51	1.22	1.27	1.29	3.98
N =	49	51	49	21	

Latent Roots		% of Discriminating Variance
1)	.1911	93%
2)	.0140	7%

Wilks' lambda = .828 ndf $_1$ = 6

ndf $_2$ = 330

F = 5.44 p = 10^{-4}

TABLE 3.14

TEACHER PREDICTIONS OF PSP

11:14

		Predictions		
		PSP	NSG	
Classifications	PSP	31	17	48
NSG	CNS	14	44	58
	NCT	12	48	60
	NCNT	7	19	26
		64	128	192

74% hits

---

* Extra time coded: 1 = 3 hrs./week +
2 = 1-3 hrs./week
3 = occasionally
4 = never

** Individual Research coded: 1 = does research
2 = yes (describe)

THE RORSCHACH TEST

Although much effort was devoted to this instrument in this investigation, the results were rather unrewarding. Since it was felt desirable not to interrupt this narrative with an extensive discussion of the manner in which these projective data were treated, those details are described in Appendix E.

All that need be said at this time is that the attributes measured by the principal components of the Rorschach scores are unrelated to educational decisions and carrer plans as classified here. This would be true regardless of the type of factor structure chosen to represent the original forty-six categories used to score the 181 protocols obtained for this age group. That is, the multivariate test of significance is the same whether principal components factor scores are used, or a Varimax or Oblimin rotation of them serves as the predictors.

TABLE 3.15
HIGH SCHOOL COURSES DISCRIMINANT ANALYSIS

	Group Means						Scaled Vectors	
	PSP	CNS	NCT	NCNT	F^{3}_{178}	F^{1}_{180}	I	II
1. Sem. Math.	5.89	5.04	5.23	3.85	7.48	10.42	0.5	14.9
2. Physics	.85	.67	.62	.54	3.15	8.13	4.5	2.0
3. Chemistry	.98	.91	.86	.88	1.52	3.77	1.6	-2.4
4. Biology*	.80	.81	.84	.85	---	---	-0.2	-1.3
5. For. Lang.	5.04	4.74	2.95	3.31	11.53	12.10	14.8	-6.9
6. Non-Acad.	3.80	4.07	4.62	3.73	---	---	.9	1.3
N	46	54	56	26				

Latent Roots	% of Discriminating Variance
1) .214	63%
2) .115	34%
3) .010	3%

Wilks' lambda = .731 $ndf_1 = 18$

$ndf_2 = 490$

F = 3.19 $p = 10^{-4}$

---

* Transcripts are for grades 10-12. Some may have taken biology in grade 9.

ENVIRONMENTAL VARIABLES

Table 3.17 and 3.18 report the results of a discriminant analysis in which selected environmental variables were used as the predictors. The primary aspect of the environment represented in the seven variables is family socio-economic status (SES). Two important variables included here, which will be explored further, are how far the parents hope the son will go in his schooling (FM[1] aspiration), and how far they expect he will go (FM expectation).

Only a single discriminant function is needed to describe the differences among these four groups, the differences being primarily college or not-college. Table 3.18 show how the PSP overlaps the CNS group. At the PSP centroid, 41% are in the CNS group. Also notice that only three boys in the PSP were not assigned to one of the two college groups on the basis of this environmental information alone. No students were assigned to the NCNT group.

TABLE 3.16
HIGH SCHOOL TRANSCRIPT DISCRIMINATIONS

		Predictor Classifications				Number in Criterion Group
		PSP	CNS	NCT	NCNT	
Grade 14 Group Membership	PSP	26	9	11	0	46
	CNS	23	17	11	3	54
	NCT	15	6	33	2	56
	NCNT	4	11	8	3	26
		68	43	63	8	182

43% hits

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT	Row Total
PSP	.39	.32	.21	.08	1.00
CNS	.30	.36	.23	.11	1.00
NCT	.23	.23	.42	.12	1.00
NCNT	.09	.37	.33	.21	1.00

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	3.89	2.06	1.54	1.01
CNS	3.55	1.59	1.46	1.28
NCT	2.57	2.19	1.64	1.22
NCNT	2.65	1.15	1.49	1.36

---

[1] Father and Mother

Inspecting the scaled vectors of Table 3.17 you see that FM expectation is the most useful predictor. This is not surprising. If you want to know whether or not an eleventh grade boy will go to college, ask his parents. However, this does not describe the situation completely. The vector tells us that it is also useful to know the mother's educational level (extent of formal education), and how far the parents hope their son will go. On the other hand, father's educational and occupational level is redundant information in this set of predictors.

The last two columns of Table 3.17 report two-group F ratios for a college vs. non-college split and for PSP vs. NSG split. An interesting trend revealed here is that mother's education appears to be slightly more important than father's education for the C vs. NC split. This is not true for the PSP vs. NSG split.

Also notice all the significant F ratios in the PSP vs. NSG column. This illustrates the importance of our four group criterion in sorting out the various relationships. These F ratios are significant because the PSP is a pure college group, whereas the NSG contains one college group (CNS) and two noncollege groups. Because these differences between PSP and CNS are not significant, it does not make sense to talk about these SES variables as being related to becoming a scientist, except in so far as one needs to go to college to become a scientist.

TABLE 3.17

ENVIRONMENT (SES) DISCRIMINANT ANALYSIS

	Group Means					CNC	PSP-NSG
	PSP	CNS	NCT	NCNT	F^{3}_{183}	F^{1}_{185}	F^{1}_{185}
1. F educational level	5.92	5.54	4.21	4.62	6.97	18.97	8.88
2. M educational level	5.29	5.32	4.21	4.00	7.76	23.18	5.49
3. F occup.level(P.Q.)*	3.00	3.16	3.70	3.50	5.07	13.89	6.76
4. FM aspiration for son	4.52	4.41	3.86	4.08	14.49	39.63	15.22
5. FM expectation for son	4.29	4.02	3.26	3.35	24.32	44.55	25.97
6. F occup.level(S.Q.)*	2.69	3.02	3.82	3.35	8.29	19.95	11.80
7. Home Scale	15.92	15.05	13.32	13.54	6.93	18.86	11.37
N =	48	56	57	26			

Scaled Vector	Latent Roots	% of Discriminating Variance
1. .75	1) .570	92%
2. 4.52	2) .035	6%
3. .29	3) .012	2%
4. 3.55		
5. 8.04		
6. -2.77		
7. -1.41		

Wilks' lambda = .608 $ndf_1 = 21$

$ndf_2 = 509$

F = 4.58 $p = 10^{-9}$

---

* (PQ) = Father's occupational level as coded from parent questionnaire.
(SQ) = As coded from student questionnaire.
Roe's (1956) scheme was used in both cases, where a "1" is high; hence the negative weight in the scaled vector.

Comparisons of the Predictor Systems

Table 3.19 summarizes the results of the discriminant analyses. Because the number of degrees of freedom varies, the most comparable index is the probability column p, which indicates the likelihood of getting four groups this different by random selection from a common multivariate population. The comparisons can only be made in terms of the actual instruments used here. For example, one cannot say that interest is more important than temperament in this process of career development. What one can say at this point is that the Kuder Preference Record does a better job of separating these four groups than does the Guilford-Zimmerman Temperament Survey. Of course one can say more if temperament is defined as that which the G-Z survey measures!

Although several different types of information are represented here, known and suspected dependencies among the various types of data demand that further probing be undertaken. For example, does the Guilford-Zimmerman Temperament Survey really offer us any information regarding the differences among these four decision groups that is not found in the Kuder? Also there is the question of differences in home environment. Is there any information here that is not reflected in the several behavioral measures? Although SES is a better predictor of college going than is aptitude and achievement, it is possible that a more careful examination of the dependencies among these several variables will be illuminating.

TABLE 3.18

ENVIRONMENT (SES) DISCRIMINATIONS

		Predictor Classifications				Number in Criterion Group
		PSP	CNS	NCT	NCNT	
Grade 14	PSP	24	21	3	0	48
Group	CNS	21	27	8	0	56
Membership	NCT	2	16	39	0	57
	NCNT	4	7	15	0	26
		51	71	65	0	187

48% hits

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT	Row Total
PSP	.41	.41	.11	.07	1.00
CNS	.35	.41	.15	.09	1.00
NCT	.06	.19	.52	.23	1.00
NCNT	.10	.25	.45	.20	1.00

Discriminant Space

	Centroids	Variances
PSP	6.03	.52
CNS	5.72	.59
NCT	4.50	1.03
NCNT	4.71	1.11

DISCRIMINATION USING SELECTED SIGNIFICANT VARIABLES

One possible next step is to combine all of the variables from all of the previous systems analyses into one grand discriminant analysis. There are several disadvantages to this approach, however, not the least of which is the fact that one would end up with more variables than members for each of the four sample groups. The alternatives are to deal with discriminant scores resulting from the systems analyses, or use selected, significantly discriminating variables. It seemed that the latter would be the more informative, so that alternative was selected.

The eighteen variables selected for inclusion in this analysis are listed in Table 3.20. Each variable is significantly related to the criterion and all are available on the cross-validation sample (8th grade to 11th grade). The extent of the group separation produced by these combined results can be seen in Table 3.21.

The analysis resulted in two major discriminant functions (Table 3.22). The first function separated the college from the non-college groups (see bottom of Table 3.21) and the second function was a science vs. non-science discriminator. The college function primarily utilized parents' expectations (how far they expect son will go in school), high school class rank, extent of mother's education, and the Guilford-Zimmerman restraint, seriousness scale, all positively related to college going.

TABLE 3.19

DISCRIMINANT ANALYSIS COMPARISONS

Predictors	Number of Variables	F	ndf_1	ndf_2	p	Primary[1] Function	Secondary Function
Kuder	10	3.32	30	520	10^{-7}	ST	C
G-Z	10	1.75	30	520	.009	C	ST
Ability	7	4.09	21	517	10^{-7}	PSP	--
Work Values	15	2.09	45	464	10^{-4}	C	--
Teacher Ratings	2	5.44	6	330	10^{-4}	PSP	--
H.S. Courses	6	3.19	18	490	10^{-4}	C	ST
SES	7	4.58	21	509	10^{-9}	C	--
Rorschach (Factor Scores)	14	1.00	42	487	.47	--	--
SVIB-AVL	16	3.54	51	403	10^{-12}	ST	C

---

[1] ST = A function which separates the science & technology groups from the two non-science-technology groups.

C = Separates college from non-college.

PSP = Separates college-science students from the other three groups.

The science-technology function weighted class rank, science interest, logical aptitude, and mechanical interest on the science end, and persuasive, clerical, and social service interests on the non-science end. The variables which did not seem at all useful in this discrimination, although individually related to the criterion, were: verbal aptitude (CMM), father's educational level, and father's occupational level. A significant variable goes unused in discriminant analysis whenever it contains essentially the same information regarding the criterion as does an even more significantly related predictor or set of predictors. These relationships will be explored further, following a consideration of the predictability of migrations.

TABLE 3.20
SIGNIFICANT VARIABLE DISCRIMINANT ANALYSIS (11:14)

		Group Means			
Kuder	F^{3}_{183}	PSP	CNS	NCT	NCNT
1. 2 - Mechanical	8.37	43.15	37.91	48.42	41.38
2. 4 - Scientific	16.32	52.56	44.96	48.74	38.50
3. 5 - Persuasive	9.92	33.04	43.09	35.82	44.35
4. 6 - Artistic	5.05	20.94	19.59	24.70	25.00
5. 9 - Social Service	2.69	39.29	43.27	37.81	35.50
6. 10 - Clerical	4.98	43.87	49.29	44.21	52.73
G-Z					
7. 2 - Restraint	6.46	16.92	15.59	12.88	14.23
8. 8 - Thoughtful	4.07	19.23	15.89	16.37	17.46
CMM					
9. 4 - Logical	2.90	23.65	22.12	22.47	22.62
10. 5 - Numerical	4.97	17.31	15.45	14.58	14.77
11. 6 - Verbal	4.65	22.77	21.00	19.68	18.42
12. 7 - Class Rank	22.64	59.71	53.16	48.14	48.77
SES					
13. 1 - F education	6.78	5.92	5.54	4.21	4.62
14. 2 - M education	7.76	5.29	5.32	4.21	4.00
15. 3 - F level	5.07	3.00	3.16	3.70	3.50
16. 4 - FM aspire	14.49	4.52	4.41	3.86	4.08
17. 5 - FM expect	24.32	4.29	4.02	3.26	3.35
18. 6 - Home Scale	6.93	15.92	15.05	13.32	13.54
N =		48	56	57	26

Latent Roots	% of Discriminating Variance
1) .958	61%
2) .489	31%
3) .135	8%

Wilks' lambda = .302 ndf$_1$ = 54

F = 4.54[1] ndf$_2$ = 495

---

[1] The probability associated with this F ratio is meaningless since these eighteen variables were selected on the basis of their individual relationship to the criterion.

These results using selected variables indicate that at least some of the dimensions from each of the domains represented here make a unique contribution to predicting membership in the four groups, either predicting college or not, or science-technology or not.

COMPARISONS OF TEACHER, INTERVIEWER, AND PARENT PREDICTIONS

In order to see how well certain adults could predict membership in the PSP, science teachers, interviewers, and parents were asked to make predictions of what the 11th grade group would be doing at grade 14. Table 3.23 reports a summary.

The only adult-predictors who seem to have been able to anticipate changes in plans were the science teachers. Their predictions were more consistent with what the students later were actually doing at grade 14 (74%) than with what the students themselves reported their later plans were at grade 11 (55%). Interviewers and parents tended to reflect current plans more than anticipate future decisions, since their per cent agreement was higher with plans at grade 11 than with actual group membership two years after high school. Unfortunately, the only systematic predictions (comparable across all students) obtained from the parents were with respect to college going.

TABLE 3.21

SIGNIFICANT VARIABLE DISCRIMINATIONS

Predictor Classifications

		PSP	CNS	NCT	NCNT	
Grade 14 Group Membership	PSP	36	9	2	1	48
	CNS	10	38	8	0	56
	NCT	4	7	42	4	57
	NCNT	0	4	7	15	26
		50	58	59	20	187

70% hits

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT
PSP	.76	.15	.08	.01
CNS	.14	.73	.11	.02
NCT	.04	.07	.77	.11
NCNT	.01	.13	.26	.60

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	10.3	3.7	1.8	3.7
CNS	9.5	0.7	1.7	4.4
NCT	7.4	3.6	2.1	3.8
NCNT	7.0	0.8	2.0	6.9

TABLE 3.22

SIGNIFICANT VARIABLE DISCRIMINANT FUNCTIONS

	Scaled Vectors		
	I	II	Variable Name
1.	-2.21	7.70	Mechanical
2.	3.09	9.73	Scientific
3.	-0.94	-12.62	Persuasive
4.	-3.01	-2.26	Artistic
5.	2.78	-7.66	Social Service
6.	-1.95	-11.44	Clerical
7.	6.28	-6.47	Restraint
8.	-4.71	3.11	Thoughtful
9.	-2.90	9.37	Logical
10.	3.30	-2.20	Numerical
11.	-0.63	-0.37	Verbal
12.	8.28	10.78	Class Rank
13.	0.63	0.28	F education
14.	7.02	-6.63	M education
15.	-0.77	2.69	F level
16.	1.92	-4.49	FM aspire
17.	8.51	-6.10	FM expect
18.	0.86	5.36	Home Scale

Function I is primarily a (+) college vs. non-college (-) discrimination.
Function II is primarily a (+) science vs. non-science (-) discrimination.

High scores on high (+) loaded variables tend to result in high discriminant scores.
High scores on high (-) loaded variables tend to result in low discriminant scores.

See Figure 3.3.

TABLE 3.23

PEOPLE PREDICTIONS

	Per Cent Consistant With	
PSP vs. NSG Predictions	Student Grade 11 Plans	Student Grade 14 Group Membership
Teachers	55%	74%
Interviewers	78%	62%
Student Grade 11 Plans	(100%)	67%
Tests*	74%	[illegible]6%
College vs. Non-College		
Parents	82%	74%
Interviewers	75%	65%
Student Grade 11	(100%)	72%
Tests*	88%	85%

---

* 18 significant variables. See Tables 3.22 & 3. for figures.

One possible contributing factor to the successful prediction by the teachers was that most of the teachers could not have been biased by grade 11 plans, simply because most of the teachers did not know current student plans. Of the 164 science teachers (some students were rated by more than one science teacher) there were 105 instances of "no knowledge of this boy's career plans" (64%). Breaking the results down a little differently, of the 92 boys in the PSP at grade 11, 43 of them had no science teacher who knew of their interest in a scientific career. The teachers reported they were using ability and interest as they observed it in the classroom as their basis for prediction.

The interview predictions were based upon a 30 minute grade 11 interview by one of out staff (doctoral candidates in guidance). The prediction was primarily based upon the interviewer's assesment of the student's commitment to his reported plans. About three-fourths of the time the interviewers accepted the stated plans as their prediction of what the student would do after high school graduation.

TABLE 3.24

SIGNIFICANT VARIABLE DISCRIMINANT ANALYSIS (11:11)

Variable	F^{3}_{183}	Group Means			
		PSP	CNS	NCT	NCNT
1. Mechanical	7.86	43.33	38.29	50.93	41.18
2. Scientific	19.86	51.87	42.22	46.00	39.12
3. Persuasive	8.97	35.20	43.86	35.10	45.35
4. Artistic	5.56	20.87	21.27	27.76	23.06
5. Soc. Service	1.33	39.99	41.37	35.48	38.18
6. Clerical	1.03	45.97	46.55	46.24	51.53
7. Restraint	5.89	16.33	14.35	13.24	11.94
8. Thoughtful	6.29	18.48	16.51	16.38	12.94
9. Logical	1.44	23.12	22.31	22.21	22.35
10. Numerical	4.80	16.57	15.14	14.48	13.41
11. Verbal	3.95	21.53	21.10	19.59	16.94
12. Class Rank	12.87	55.54	53.43	46.21	46.53
13. F education	1.70	5.30	5.25	4.83	4.06
14. M education	1.24	4.99	4.80	4.45	4.29
15. F level	1.07	3.23	3.29	3.59	3.53
16. FM aspiration	11.18	4.41	4.27	3.76	3.88
17. FM expectation	29.77	4.07	3.96	3.07	2.76
18. Home Scale	3.49	14.96	15.02	13.34	12.88
N =		90	51	29	17

Latent Roots	% of Discriminating Variance
1) .809	64%
2) .356	28%
3) .108	8%

Wilks' lambda = .368

$ndf_1 = 54$

$ndf_2 = 495$

F = 3.66

Predictions of Migrations

One of the major "theoretical" questions relevant to this investigation is whether or not the attributes measured at eleventh grade are simply a function of current plans or determine future plans. For example, some would say that a student responds to the Kuder as he thinks a chemist would, if at that time he is planning to become a chemist As his career plans and goals shift, so would his responses to the Kuder.

On the other hand, one might argue that the Kuder measures much more than a current occupational interest, that it measures an aspect of personality which is more stable than current career plans. In this section some evidence related to this question is examined.

First of all a discriminant analysis of the eighteen significant variables was performed using group membership at grade eleven rather than grade fourteen as the criterion. Comparing Tables 3.20 and 3.24 one will notice that the generalized variance ratio was lower for the earlier grade. This means that the four groups in this eighteen dimensional space were further apart and more homogeneous (smaller within group variation) two years after high school than they were at grade eleven when the attributes were measured. This seems to support the position that the future plans are a function of the attributes measured, rather than attributes being a function of plans current at the time of measurement.

TABLE 3.25

SIGNIFICANT VARIABLE DISCRIMINANT ANALYSIS

11:11 Predictor Classifications

		PSP	CNS	NCT	NCNT	
Grade 11 Group Membership	PSP	73	13	4	0	90
	CNS	21	29	1	0	51
	NCT	8	2	16	3	29
	NCNT	3	3	3	8	17
		105	47	24	11	187

67% hits

Probabilities of Group Centroids

	PSP	CNS	NCT	NCNT	
PSP	.77	.19	.04	.00	1.00
CNS	.35	.58	.05	.02	1.00
NCT	.27	.10	.49	.14	1.00
NCNT	.05	.18	.27	.50	1.00

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	10.6	12.7	1.36	3.57
CNS	9.6	10.6	1.25	4.37
NCT	8.5	14.0	1.40	3.83
NCNT	7.5	11.7	1.35	3.33

Further inspection of the two tables reveals that fourteen of the eighteen univariate F ratios increased four years later from those based on eleventh grade membership. This seems to be further evidence of a shift in plans which is more consistent with previously measured attributes. Notice, however, which variables became more significant and which did not. All of the aptitude-achievement measures became more significant, indicating that group membership(career plans) is more consistent with these attributes after high school than during high school. Five of the six SES measures were more highly related to grade 14 reality than to grade 11 plans. These variables must be interpreted differently, however, since they are attributes of the student's environment, where the others are behavioral measures. Here we simply need to say that the post-high school decisions of these boys were more consistent with their family socio-economic status than were their plans at eleventh grade.

The picture is not so clear with respect to the interest and temperament variables. Although most of the F ratios increase, three do not; one of which is a key Kuder variable, scientific interest. Further analyses were necessary to clarify this situation. Discriminant analyses for the Kuder interest and G-Z temperament systems, using eleventh grade group membership, were conducted using all ten scales from each system.

The results of these two analyses were also inconclusive. The Kuder scales had a slightly reduced generalized F ratio after four years (3.50 to 3.32), while the G-Z temperament scales increased slightly (1.56 to 1.75). How much confidence can we have in the statement that the decisions made during these four years were more or less consistent with temperament or interest? In this situation of "partially correlated" groups and completely identical score vectors, the question is apparently unanswerable (some students are in the same groups, some are not; the same predictor scores for an individual are used in both analyses). One thing we can be sure of, there were not the dramatic increases in the F ratios as there were with aptitude and socio-economic information.

The conclusion from this series of analyses is that aptitude and SES information become more highly related to group membership as students move from eleventh-grade college plans to post-high school reality, whereas interest and temperament information is as much related to plans as it is to actual decisions.

In an effort to further clarify the relationship of the Kuder to future plans, a stepwise-multiple correlation was performed, using science-technology (ST) plans at grade 14 as the criterion. That is, the PSP and NCT groups (ST) were compared to the CNS and NCNT groups (NST). In addition to the ten Kuder scales, the grade 11 plans, coded ST = 1 and NST = 0, were used as a predictor.

A brief description of how this stepwise program operates may be useful in understanding these results. First of all, the 12th order correlation matrix is produced, using point biserial correlations between Kuder scales, the binary coded grade 11 and 14 plans, and a phi coefficient between plans. The eleven correlations with the criterion (grade 14 plans) are inspected, and the largest coefficient is selected out as the best predictor. In this case, grade 11 plans (r = .39) had the highest coefficient, although science (.38) and persuasive (-.37) interests are related to a similar degree.

The next step is to form partial correlations between predictors and criterion, with grade 11 plans partialled out. The partial r will be reduced to zero if it contains the same information regarding the criterion as does the variable being partialled out. The variable having the highest partial with the criterion is then selected as the next best predictor, and this is added to the previously selected predictor, forming a multiple correlation with the criterion. This new predictor is then partialled out, forming second order partials with the criterion, and the process continues until no new significant information remains in the unused predictors. Table 3.26 summarizes the results of this analysis.

As has been pointed out elsewhere,* this stepwise technique presents certain difficulties in making inferences from the sample. For example, one cannot conclude from these results that Kuder scientific scale is useless in predicting grade 14 plans, simply because that scale made no significant increase in the multiple regression. In a subsequent sample, the science interest scale might be correlated a few hundredths higher than the grade 11 plans, and then grade 11 plans would appear useless.

However, a general conclusion can certainly be drawn from these results. The Kuder is a useful instrument for understanding movement away from careers in science and technology because it contains information regarding future decisions beyond that found in stated career plans. In a sense, this information is of a negative type, for it concerns what the student would or would not be willing to do as an alternative to science and technology. Students who are high on persuasive, social service, and clerical interests, will move away from careers in science and technology, whether or not they rated high on science interest scale originally. This seems to explain the reduced F ratio for the scientific scale when comparing the groups at grade 11 and grade 14. One might conclude from these results that some of the students who move away from careers in science and technology did not fully understand that career (or themselves).

TABLE 3.26

PREDICTION OF SCIENCE-TECHNOLOGY PLANS AT GRADE 14 USING KUDER AND GRADE 11 PLANS

Predictor	Zero order correlation	1st order partials	2nd order partials	3rd order partials	4th order partials
1. Outdoor	.17	.15	.04	-.07	-.10
2. Mechanical	.28	.21	.16	.14	.09
3. Computational	.05	-.03	-.07	.05	.05
4. Scientific	.38	.25	.16	.13	.13
5. Persuasive	-.37	-.27			
6. Artistic	.10	.08	.04	.01	-.08
7. Literary	-.11	-.04	-.01	-.05	-.08
8. Musical	-.00	.03	.01	.01	-.04
9. Social Service	-.10	-.08	-.06	-.17	
10. Clerical	-.25	-.25	-.23		
11. Grade 11 Plans	.39				
Predictor Added	11	5	10	9	4
Multiple R	.39	.46	.50	.52	.54
Variance explained (R^2)	.15	.21	.25	.27	.29
F ratio for increase**	32.87	14.57	10.38	5.53	3.22

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* See for example Cooley and Lohnes (1962)

*** Number of degrees of freedom are 1 and 188; $F_{.05} = 3.89$

Relationships Among The Predictors

This section reports an attempt to achieve a better understanding of the predictors by examining certain types of relationships which exist among the predictors. This was done in an attempt to obtain a better understanding of the functional relationships between predictors and career patterns.

BIVARIATE RELATIONSHIPS

Perhaps it would be useful to begin by examining the bivariate relationships[1] which exist among the significant variables from the different domains. Table 3.27 is the complete intercorrelation matrix for the eighteen variables of Table 3.20. A correlation greater than .19 is significant at the .01 level. Outside of the expected correlations within domains, the following significant relationships are found:

1. Mechanical interest is negatively related to restraint, class rank, and parent educational aspirations.

2. Science interest is positively related to verbal aptitude, class rank, and parent educational expectations.

3. Persuasive interest is negatively related to restraint.

4. Artistic interest is negatively related to parent educational expectations.

7. Restraint is positively related to class rank and parent educational aspiration and expectation; negatively related to mechanical and persuasive interest.

8. Thoughful is positively related to class rank and parent educational expectations.

10. Numerical aptitude is positively related to class rank and home scale.

11. Verbal aptitude is positively related to science interest, class rank, and parent education aspirations and expectations.

12. Class rank is significantly related to eight variables, and will be dealt with below.

16. Parent expectations is positively related to science interest, restraint, thoughtful, verbal aptitude, and class rank; negatively related to artistic interest.

18. Home scale is positively related to numerical aptitude.

Several questions are suggested by these relationships. For example, how should parent expectation be viewed? Does this variable reflect an environmental

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[1] Using Pearson product movement correlation coefficients.

TABLE 3.27

INTERCORRELATIONS OF SIGNIFICANT VARIABLES

	1	2	3	4	5	6	7	8	9
1. Mechanical	1.00	0.23	-0.29	0.21	-0.24	-0.14	-0.23	-0.15	-0.11
2. Scientific	0.23	1.00	-0.49	-0.17	0.01	-0.22	0.11	0.19	0.11
3. Persuasive	-0.29	-0.49	1.00	-0.16	0.08	0.12	-0.22	-0.18	0.04
4. Artistic	0.21	-0.17	-0.16	1.00	-0.37	-0.16	-0.07	-0.03	-0.13
5. Soc. Service	-0.24	0.01	0.08	-0.37	1.00	-0.37	-0.09	-0.02	0.15
6. Clerical	-0.14	-0.22	0.12	-0.16	-0.37	1.00	0.19	-0.06	-0.14
7. Restraint	-0.23	0.11	-0.22	-0.07	-0.09	0.19	1.[illegible]	0.48	0.02
8. Thoughtful	-0.15	0.19	-0.18	-0.03	-0.02	-0.08	0.48	1.00	0.10
9. Logical	-0.11	0.11	0.04	-0.13	0.15	-0.14	0.02	0.10	1.00
10. Numerical	-0.07	0.15	0.05	-0.11	-0.04	0.03	0.05	0.06	0.38
11. Verbal	-0.05	0.20	-0.01	-0.06	-0.03	-0.08	0.12	0.09	0.16
12. Class Rank	-0.26	0.19	-0.05	-0.14	-0.06	0.09	0.34	0.28	0.11
13. F education	0.01	-0.00	-0.03	-0.11	0.05	-0.03	0.01	-0.03	0.03
14. M education	0.02	0.04	-0.04	-0.06	-0.00	-0.04	-0.08	-0.14	0.12
15. F level	0.04	0.03	-0.00	0.10	-0.09	0.10	0.04	0.05	-0.08
16. FM aspiration	-0.22	0.10	0.02	-0.19	0.09	-0.05	0.23	0.18	0.10
17. FM expectation	-0.15	0.21	-0.03	-0.26	0.11	-0.09	0.25	0.23	0.19
18. Home scale	0.03	-0.03	0.08	-0.06	-0.02	-0.13	-0.05	-0.05	0.14

	10	11	12	13	14	15	16	17	18
1. Mechanical	-0.07	-0.05	-0.26	0.01	0.02	0.04	-0.22	-0.15	0.03
2. Scientific	0.15	0.20	0.19	-0.00	0.04	0.03	0.10	0.21	-0.03
3. Persuasive	0.05	-0.01	-0.05	-0.03	-0.04	-0.00	0.02	-0.03	0.08
4. Artistic	-0.11	-0.06	-0.14	-0.11	-0.06	0.10	-0.19	-0.26	-0.06
5. Soc. Service	-0.04	-0.03	-0.06	0.05	-0.00	-0.09	0.09	0.11	-0.02
6. Clerical	0.03	-0.08	0.09	-0.03	-0.04	0.10	-0.05	-0.09	-0.13
7. Restraint	0.05	0.12	0.34	0.01	-0.08	0.04	0.23	0.25	-0.05
8. Thoughtful	0.06	0.09	0.28	-0.03	-0.14	0.05	0.18	0.23	-0.05
9. Logical	0.38	0.16	0.11	0.03	0.12	-0.08	0.10	0.19	0.14
10. Numerical	1.00	0.41	0.36	0.07	0.09	-0.07	0.14	0.15	0.22
11. Verbal	0.41	1.00	0.41	0.14	0.12	-0.14	0.20	0.22	0.14
12. Class Rank	0.36	0.41	1.00	0.14	0.06	-0.14	0.30	0.41	0.10
13. F education	0.07	0.14	0.14	1.00	0.54	-0.77	0.24	0.29	0.61
14. M education	0.09	0.12	0.06	0.54	1.00	-0.44	0.19	0.19	0.57
15. F level	-0.07	-0.14	-0.14	-0.77	-0.44	1.00	-0.23	-0.24	-0.54
16. FM aspiration	0.14	0.20	0.30	0.24	0.19	-0.23	1.00	0.57	0.28
17. FM expectation	0.15	0.22	0.41	0.29	0.19	-0.24	0.57	1.00	0.37
18. Home scale	0.22	0.14	0.10	0.61	0.57	-0.54	0.28	0.37	1.00

influence; i.e., do students go to college *because* their parents expect them to go? Or do parents report high expectations *because* feedback from school (i.e. grades, student attitudes, etc.) suggests the student could and would pursue college studies successfully?

Also, how can the complex variable of class rank be fitted into an explanation of movement into scientific careers? Several different kinds of tested behavior appear to be related. A better understanding of class rank and of FM expectations is needed before those two variables can be put into a meaningful context.

CLASS RANK MULTIPLE CORRELATIONS

In order to reach a better understanding of class rank, multiple correlation was used with class rank as the dependent variable. Using seventeen predictors, a multiple correlation of .65 was obtained (Table 3.28). This very significant relationship is surprisingly high in view of the difficulty inherent in obtaining a comparable score for

TABLE 3.28

MULTIPLE CORRELATION WITH CLASS RANK

	17 Predictors	7 Predictors
	$R_1 = .65$	$R_2 = .60$
N = 187	$R_1^2 = .43$	$R_2^2 = .36$
	$F = 7.35$	$F = 14.09$
	$p = 10^{-6}$	$p = 10^{-11}$

		r_{ic}*	Beta Wt.**	t-test***	Beta Wt.	t-test
1.	Mechanical	-.26	-.18	-2.63	-.19	-3.01
2.	Scientific	.19	.08	1.00	.13	1.89
3.	Persuasive	-.05	.01	---		
4.	Artistic	-.14	.01	---		
5.	Social Service	-.06	-.08	---		
6.	Clerical	.09	.06	---	.08	1.28
7.	Restraint	.34	.12	1.61	.17	2.33
8.	Thoughtful	.28	.09	1.28	.11	1.62
9.	Logical	.11	-.08	-1.21		
10.	Numerical	.36	.24	3.36	.20	3.06
11.	Verbal	.41	.22	3.32	.27	4.02
12.	F education	.14	.01	---		
13.	M education	.06	.01	---		
14.	F level	-.14	-.10	-1.04		
15.	FM aspir.	.30	-.00	---		
16.	FM expect.	.41	.28	3.54		
17.	Home scale	.10	-.12	-1.32		

Test of $R_1^2 = R_2^2$:
$F = 2.06$ with $ndf_1 = 10$
$ndf_2 = 169$
$p = .05$

* Correlation with criterion
** Standard partial regression
*** Test of Beta = 0

class rank for the nine different school systems. The fact that all these boys were in college preparatory curriculum made class ranks more comparable; but this in turn increased homogeneity on aptitude measures. The variables making major contributions to prediction in this combination of predictors were: FM expectations, numerical and verbal aptitude loaded positively; and mechanical interest loaded negatively.

To obtain a better estimate of the contribution of the six SES variables to class rank prediction, a regression was performed using the best seven non-SES variables. The two right-hand columns of Table 3.28 indicate the seven predictors which produced a multiple correlation of .60. Although it is possible to reject the hypothesis that $R_1^2 = R_2^2$ at the .05 level, certainly very little information relative to rank in class is contained in the SES variables that is not found in these seven behavioral measures. Notice the increased importance of the GZ restraint scale when the SES variables are not in the battery.

UNIQUE CONTRIBUTION OF SES

In an effort to further explore the contribution of the SES variables to the prediction of group membership, generalized analysis of variance with covariance adjustment was conducted.[1] Here we asked two questions: 1) Are there any differences in the four groups (PSP, CNS, NCT, and NCNT) on the SES variables after adjustment for initial differences on interest, temperament and aptitude? 2) Are there any differences on interest, temperament and aptitude after adjusting for initial SES differences?

Significant variance ratios were obtained in both analyses. This suggests that both behavioral measures and environmental measures are needed to predict (understand) the types of career decisions which are indicated by membership in these four groups.

TABLE 3.29

OBSERVED AND ADJUSTED MEANS FOR THE SES VARIABLES

	PSP	CNS	NCT	NCNT
1. F education	5.92	5.54	4.21	4.62
adjusted	6.02	5.56	4.13	4.56
2. M education	5.29	5.32	4.21	4.00
adjusted	5.42	5.46	4.00	3.92
3. F level	3.00	3.16	3.70	3.50
adjusted	2.96	3.16	3.72	3.54
4. FM aspire	4.52	4.41	3.86	4.08
adjusted	4.43	4.37	3.94	4.15
5. FM expect	4.29	4.02	3.26	3.35
adjusted	4.08	4.03	3.36	3.52
6. Home Scale	15.92	15.06	13.32	13.54
adjusted	16.10	15.22	13.10	13.15

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[1] See Cooley and Lohnes (1962) Chapter 4, for a description of this technique.

One of the interesting trends revealed by these covariance adjustment analyses is that differences of four SES measures increased after adjustment, while group differences on parents' aspirations and expectations diminished (Table 3.29). For those differences which increased (father's occupational level, F and M educational level, and home scale) this means that differences among the four groups on these variables were greater than you would expect from knowing their scores on the behavioral measures. Where the differences diminished, one might say that the differences among the four groups on these variables are in part due to the types of behavior which exposure to this type of environment produced. However, as far as FM expectations are concerned, this variable is probably a function of the behavior rather than a cause of it.

One conclusion which can be drawn from this series of analyses is that the PSP group is slightly higher on aptitude and achievement than you would expect from knowing the socio-economic status of their families. Actually this trend was revealed in two of the discriminant analyses. That is, in spite of an over-all correlation between aptitude-achievement and SES, there were no differences between the PSP and CNS groups on SES, yet high differences were found for aptitude-achievement predictors.

CANONICAL CORRELATIONS AMONG DOMAINS

A second but quite different approach to the question of the relationship between the SES measures and the interest, temperament and aptitude measures, is the use of canonical correlation. The covariance analyses asked whether or not the one set of variables contained information regarding group differences not found in the other set. The results indicated that unique information regarding group differences is found in both sets.

In canonical correlation, the extent of the overlap between the two sets of variables is examined, without regard to group membership information. Although each set may contain unique information regarding group membership, it may also contain common information. Canonical and multiple correlation are useful in asking this latter question.

As part of his thesis investigation, Jones (1963) made extensive canonical analyses of these data to explore this question of informational overlap. These results are summarized in Appendix B.

TABLE 4.1

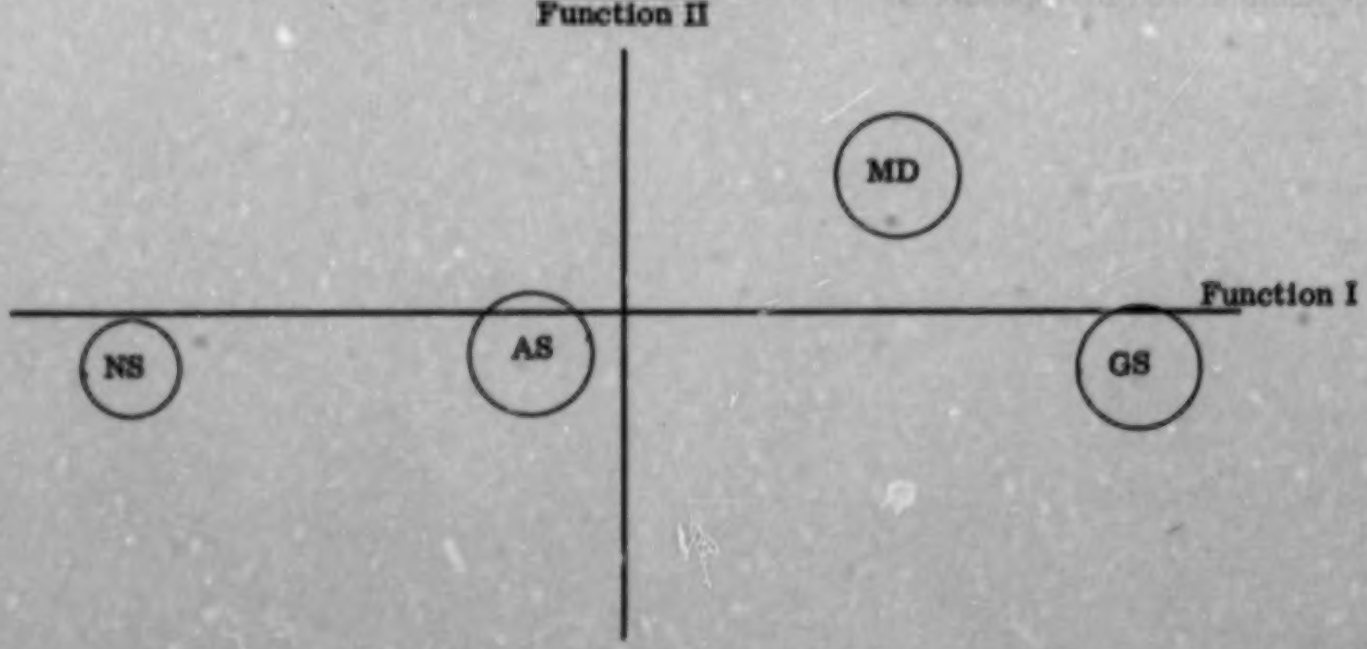
GRADE 14 MAJOR AND SUBSEQUENT CRITERION GROUPS

		College Sophomore Major					
		Biology	Engineering	Chemistry	Geology	Physics	
Grade 14 Plans	GS	1	7	17	8	23	56
	MD	25	0	4	0	1	30
	AS	0	13	1	1	6	21
	NS	2	0	1	0	2	5
		28	20	23	9	32	112
Grade 18 Plans and Decisions	GS	4	1	9	1	17	32
	MD	18	0	3	0	2	23
	AS	1	9	4	5	11	30
	NS	5	10	7	3	2	27
		28	20	23	9	32	112

		Grade 14 Plans				
		GS	MD	AS	NS	
Grade 18 Plans and Decisions	GS	28	4	0	0	32
	MD	0	22	0	1	23
	AS	17	0	13	0	30
	NS	11	4	8	4	27
		56	30	21	5	112

FIGURE 4.1

SVIB INTEREST DISCRIMINANT SPACE



CHAPTER 4

THE COLLEGE TO POST-COLLEGE TRANSITION

The primary reason for including the college science and engineering students in this investigation is to examine both the process of deciding upon a particular occupational area within science, and the movement out of science, during the college and post-college years. The eleventh graders were useful in studying the general orientation toward science in the transition from high school to college. Further refinements can be studied in the older group.

There are several different ways of defining criterion groups for college science students. Tables. 4.1 and 4.2 illustrate two possible ways for classifying the two college groups, initially sophomores or seniors. The obvious way to classify them is by major field of study within science. This criterion is compared to a four group scheme which serves as the basis for the first series of analyses reported in this chapter.

TABLE 4.2

GRADE 16 MAJOR AND SUBSEQUENT CRITERION GROUPS

		College Senior Major					
		Biology	Engineering	Chemistry	Geology	Physics	
	GS	1	0	9	3	20	33
Grade 16	MD	16	0	2	0	2	20
Plans	AS	2	16	5	6	7	36
	NS	4	2	2	0	3	11
		23	18	18	9	32	100
Grade 20	GS	4	1	7	4	18	34
Plans	MD	12	0	1	0	2	15
and	AS	2	6	7	4	7	26
Decisions	NS	5	11	3	1	5	25
		23	18	18	9	32	100

		Grade 16 Plans				
		GS	MD	AS	NS	
Grade 20	GS	25	4	5	0	34
Plans	MD	0	15	0	0	15
and	AS	7	0	17	2	26
Decisions	NS	1	1	14	9	25
		33	20	36	11	100

The group definitions below are followed by actual examples to illustrate the group composition.

1. Graduate school in science (GS): These boys graduated from college as science majors and went on to graduate work in science, with at least some interest in research as part of their career plans.

   Illustrative Plans: basic research in astrophysics, physicist, medical research, teach and research physical-chemistry, research and administration in nuclear engineering, oceanography, etc.

2. Medical and Dental School (MD): These boys entered a medical or dental school following graduation with the intention of entering clinical practice. Those interested in research and teaching were classified in group GS.

   Illustrative Plans: general medical practice, neurology or possibly psychiatry, specialize in internal medicine, dental surgeon, etc.

3. Applied Sciences (AS): These boys did not go on to graduate work, they entered occupations in science and technology, at a junior scientist or engineering level.

   Illustrative Plans: electrical engineer, junior physicist, mechanical engineer, chemist, meteolologist, etc.

4. Non-Science (NS). These boys decided not to enter fields in science and technology. However, they often entered careers which would take advantage of their science-technology background, such as industrial management.

   Illustrative Plans: business management, librarian-writer, sales engineer, German teacher, banking, business-finance, industrial psychologist, etc.

The top of Table 4.1 shows the relationship between undergraduate major and membership in one of the four criterion groups as of the sophomore year. At that time only five boys were considering leaving science. One-half of the group was planning graduate work in one of the sciences. Only one biology major was planning graduate work. From these results it appears that the biology departments represented here spent most of their time preparing pre-medical students.

Five years later ("grade 18") the situation was slightly different. The number of students in graduate school is just a little over one-half the number who had planned to go. All but biology contributed approximately equal numbers to the "drop-out", but proportionally, the large changes away from graduate work were among the engineering and geology majors.

The bottom row of the middle table shows that very few physics majors leave science. If they do not go on to graduate work they go directly into industry as junior physicists. Engineering and chemistry majors are the two largest contributors to the non-science group.

The bottom of Table 4.1 shows the relationship between Grade 14 plans and group membership at Grade 18 (two years post-college). Of the fifty-six planning graduate work at grade 14, one-half of them were in graduate school following college graduation. The others went directly to work in applied science or left science for other types of positions. Sixty per cent of the students had grade 18 decisions and plans which were consistent with grade 14 plans.

Table 4.2 outlines group membership for the college senior group. The trends here are similar to the previous table, except that the top and middle of Table 4.2 both resemble the middle of Table 4.1. This reflects the fact that by the senior year the plans are fairly stable. The only large off-diagonal element in the bottom of Table 4.2 is the change from applied science to non-science, primarily on the part of the engineers.

The next section of this chapter explores the differences among these four criterion groups. These analyses are followed by discriminations among major fields and among colleges, in an attempt to further understand the process of choosing a career within science or moving out of science.

TABLE 4.3

SVIB INTEREST

Discriminant Analysis

	Group Means				
	GS	MD	AS	NS	F^{3}_{86}
1. Professional	51.39	48.86	43.71	38.64	13.58**
2. Technical	50.24	42.00	45.52	41.05	4.76**
3. Production	33.15	30.79	35.62	39.55	3.42*
4. Active	33.30	32.43	35.38	38.68	1.29
5. Welfare	37.03	41.00	36.71	39.45	---
6. Musical	44.45	42.14	37.33	35.09	3.87*
7. CPA	33.94	30.00	31.86	28.09	1.81
8. Bus. Detail	19.00	23.14	29.10	29.41	8.44**
9. Bus. Contact	27.94	33.43	31.81	37.00	6.70**
10. Verb.-Ling.	44.42	42.86	39.62	37.77	4.38**
11. Pres. Mfg.	30.67	30.14	30.33	33.32	---

	Scaled Vectors	
Variable	I	II
1.	54	56
2.	12	-12
3.	-18	-15
4.	-15	9
5.	16	21
6.	-16	-28
7.	3	-4
8.	16	25
9.	-31	14
10.	10	-13
11.	2	6

Latent Roots	% of Discriminating Variance
1) .5807	58%
2) .2905	29%
3) .1312	13%

Wilks' lambda = .433

$F = 2.23$ $ndf_1 = 33$

$p = .0005$ $ndf_2 = 225$

---

* Sig. at .05 level

** Sig. at .01 level

Discriminant Analyses of the Four Criterion Groups

The four groups defined in the previous section served as the criterion for the following series of discriminant analyses. These groupings were used rather than college major since they are more related to the types of decisions which the boys had to make following college graduation: (1) going on to graduate work in science, with a research interest generally involved (GS); (2) going on to medical or dental school (MD); (3) going right to work in applied science (AS); (4) Leaving science for another type of work (NS).

It was expected that on "people-oriented" variables, the NS and MD groups would cluster at the high end, with GS and AS at the low end. On abilities, the GS and MD group would be higher than the AS and NS groups. In other respects, this was somewhat of a "fishing expedition," to determine the other personality patterns which would be associated with membership in these four groups.

TABLE 4.4

SVIB INTEREST DISCRIMINATIONS

Probabilities for Group Centroids

(Senior Data)

	GS	MD	AS	NS	Row Total
GS	.72	.02	.18	.08	1.00
MD	.09	.56	.33	.02	1.00
AS	.33	.08	.37	.22	1.00
NS	.07	.02	.30	.61	1.00

Discriminant Space

	Centroids		Variances	
	I	II	I	II
GS	33.8	31.5	44.3	4.10
MD	30.4	35.4	62.9	2.41
AS	26.9	32.6	54.4	11.35
NS	19.3	32.0	79.6	6.77

Sophomore Group Predictions

		GS	MD	AS	NS	
Post-College Group Membership	GS	19	4	5	2	30
	MD	2	6	4	9	21
	AS	14	2	3	10	29
	NS	4	5	3	14	26
		39	17	15	35	106

40% hits

Before going into the details of the nine analyses, a summary of the overall ways in which the groups actually did differ may be useful.

SUMMARY OF THE DISCRIMINANT ANALYSES

Interests: Two functions are needed to describe the differences among the four groups on expressed interests. On the first function, the GS and MD are high, primarily because of a similar pattern of professional interests. The second function singles out the MD group because of a unique combination of high professional and people-contact interests together with low technical worker interest.

Values: A single function was able to separate these groups, indicating that the relative differences among the groups was similar for each of the values scales. The major defining variable was theoretical values, the ranking from high to low being GS, MD, AS and NS. The one exception to this relative ordering of the groups (either high to low or low to high) was on social values, in which in MD group was high and GS group was low. The social values differences were too slight however to define a second function in which one could have confidence.

Temperament: Of the two functions which resulted from the ten temperament scales, the main function is primarily a people-oriented function, with social interest and personal relations loaded positively. The ordering of the groups was, from high to low: NS, MD, AS and GS.

The second function separated the AS group from the rest, primarily utilizing their unique pattern of low general activity and high masculinity.

TABLE 4.5
AVL VALUES
Discriminant Analysis

	Group Means				
	GS	MD	AS	NS	F^{3}_{86}
1. Theoretical	56.42	53.64	50.05	49.05	8.45**
2. Economic	34.85	34.71	40.00	39.05	2.87*
3. Athletic	42.82	38.93	34.62	35.41	4.50**
4. Social	32.45	37.71	34.57	33.77	1.63
5. Political	37.85	39.79	41.57	41.55	2.08

Scaled Vector		Latent Roots	% of Discriminating Variance
1.	49	1) .4403	85%
2.	-18	2) .0669	13%
3.	24	3) .0097	2%
4.	-9		
5.	-15		

Wilks' lambda = .644

F = 2.61 ndf $_1$ = 15

$p < .001$ ndf $_2$ = 227

Home Background: The only other set of predictors which was statistically significant at the .05 level contained environmental information. The useful predictors here were not measures of socio-economic status, but rather variables such as religion, ordinal position, and type of father's employment. Two functions were useful in separating the four groups. The major function separated GS and AS from NS and MD, while the second function separated MD and GS from AS and NS.

Unrelated variables: Five of the systems which were expected to be predictive of group membership were found to be unrelated. They were two projective tests (Rorschach and TAT), scholastic ability, general activities information, and patterns of courses elected in high school.

TABLE 4.6

AVL VALUES DISCRIMINATIONS

Probabilities for Group Centroids

(Senior Data)

	GS	MD	AS	NS	Total
GS	.55	.17	.13	.15	1.00
MD	.35	.16	.26	.23	1.00
AS	.14	.14	.40	.32	1.00
NS	.13	.14	.40	.33	1.00

Discriminant Space

	Centroids I	Variances I
GS	39.0	43.4
MD	34.3	93.4
AS	28.5	43.5
NS	28.2	66.2

Sophomore Group Predictions

		GS	MD	AS	NS	
Post-College Group Membership	GS	19	0	10	1	30
	MD	8	0	12	1	21
	AS	9	0	16	4	29
	NS	6	0	15	5	26
		42	0	53	11	106

38% hits

DETAILS OF THE DISCRIMINANT ANALYSES

INTEREST

The Strong Vocational Interest Blank (SVIB) was the instrument used to assess the interests of the college students. The Blanks were scored for the eleven group scales, rather than for specific occupations. The scales are defined in Appendix A. The differences among the four criterion groups are shown in Table 4.2. The overall differences, using the Wilks lambda criterion, are significant at the .0005 level. The univariate F-ratios are useful in comparing the discriminating power of the variables when used alone, and the scaled vectors show their relative contribution on the first two discriminant functions, when these eleven variables are used in combination. In both cases, the Professional Worker scale stands out as the most useful predictor, with graduate students in science the highest group, and the boys leaving science the lowest group.

TABLE 4.7

GZ TEMPERAMENT

Discriminant Analysis

	Group Means				
	GS	MD	AS	NS	F^{3}_{86}
1. Gen. Activity	16.24	17.57	13.00	20.36	6.59**
2. Restraint	18.21	18.86	19.29	17.73	----
3. Ascendance	14.97	15.14	14.52	17.77	1.75
4. Social Interest	14.30	17.36	14.52	21.05	6.08**
5. Emotional Stability	15.79	15.14	16.10	19.23	2.19
6. Objectivity	18.79	16.21	17.81	19.82	1.58
7. Friendliness	14.97	14.64	14.00	14.23	---
8. Thoughtful	20.61	19.79	20.90	19.73	---
9. Pers. Relations	14.91	16.71	16.52	18.77	2.38
10. Masculinity	19.36	19.21	21.95	21.95	3.13*

	Scaled Vectors	
	I	II
1.	9	-27
2.	6	10
3.	-15	-6
4.	28	1
5.	10	8
6.	-22	-9
7.	- 9	-16
8.	1	2
9.	16	11
10.	17	24

Latent Roots	% of Discriminating Variance
1) .459	55%
2) .276	34%
3) .093	11%

Wilks' lambda = .491

$F = 2.07$ $ndf_1 = 30$

$p < .005$ $ndf_2 = 227$

---

* Sig. at .05 level
** Sig. at .01 level

Figure 4.1 shows the relative locations of the centroids of the four groups in the discriminant space. The location of a group centroid is determined by the pattern of means on the eleven scales. Although both discriminant functions make much use of the professional worker scale, the difference is in what pattern goes with it. For example, the scaled vectors reveal that the business contact scale is negatively loaded on function I and positive on function II. This combination, in part, contributes to the low Non-Science (NS) group score on function I and the high Medical-Dental (MD) score on function II. The NS group was not high on function II, in part because of the low professional worker scale. Or saying this in another way, both the MD and NS groups are interested in people-contact, but the MD group expresses a much higher "professional" interest than does the NS group. Since most of the discriminating variance in this interest test is reduced to only two functions, it can be concluded that the four groups differ in only two basic ways.

Table 4.4 provides information related to the overlap among the groups. At the top of the table, the probabilities of group centroids are the proportions of each group which make up those at the mean of the group. For example, of the people with scores similar to the GS means, 72% are in the GS group, 2% are in the MD group, 18% in the AS group, and 8% in the NS group. The most poorly defined group is the applied science

TABLE 4.8

GZ DISCRIMINATIONS

Probabilities for Group Centroids

(Senior Data)

	GS	MD	AS	NS	
GS	.61	.14	.15	.10	1.00
MD	.30	.19	.18	.33	1.00
AS	.26	.14	.47	.13	1.00
NS	.11	.19	.16	.54	1.00

Discriminant Space

	Centroids		Variances	
	I	II	I	II
GS	13.1	2.48	9.50	13.00
MD	16.5	2.71	14.47	18.15
AS	15.3	7.12	14.19	14.11
NS	18.9	2.77	11.08	12.01

Sophomore Group Predictions

		GS	MD	AS	NS	
Post-College Group Membership	GS	15	1	7	7	30
	MD	7	1	4	9	21
	AS	10	0	9	10	29
	NS	6	0	6	14	26
		38	2	26	40	106

37% hits

group, which overlaps the GS and NS groups in interest. It is this confusion which accounts for much of the error in predicting sophomore groups membership from interests alone (bottom Table 4.4). These sophomore predictions are made using the prediction equations based upon the senior group data. As can be seen in the bottom table, this cross-validation holds up fairly well.

The other major source of error in prediction is that some of the MD group were predicted to be in the NS group. These are the types of confusions expected for the interest data.

VALUES

The Allport-Vernon-Lindzey Study of Values was the instrument used to measure values in this investigation. The difference in values among the groups was significant at the .001 level, with only one discriminant function needed to discriminate among the four groups. Because of a pattern of high theoretical and aesthetic values, with low economic, the GS group was the highest group on the function (see centroids, Table 4.5). Having a similar pattern on the first three values, the MD group is lower than GS on the function because the MD's had higher scores on two negatively loaded scales, social and political.

The other two groups, AS and NS, have an almost identical pattern of values, as is revealed in both the scale means and the discriminant space centroid. These two groups are indistinguishable as far as the values measured by the AVL are concerned.

The sophomore predictions yielded slightly fewer hits (38% hits) than did the eleven scales on the SVIB. One of the major reasons for error was the greater heterogeneity (see discriminant space variances - Table 4.6) of the MD group, resulting in no assignments to that group by the highest probability prediction system.

TEMPERAMENT

The Guilford-Zimmerman Temperament Survey was the instrument used in this analysis. The probability that these four groups are random samples from a common multivariate population is less than .005. Two discriminant functions appear to be necessary to distinguish among these four groups.

The high group on the first function is the non-science group, followed by MD and AS in the middle, and the GS group lowest. The primary defining variable is social interest, positively loaded, together with personal relations and masculinity. Objectivity and ascendance are negatively loaded.

On the second function, the applied scientists are singled out, primarily by their pattern of low general activity and high masculinity scores. The other three groups are indistinguishable from each other on this second function.

The extent to which these ten temperament variables are able to predict group membership for the sophomores is seen at the bottom of Table 4.8. The GZ is about as good a predictor as the AVL, with a similar pattern of misses. In both cases the MD group was way underassigned, but in the case of the GZ temperament scales, the non-science group was overassigned, rather than the applied science group, as was the case with the AVL values scales.

TABLE 4.9

CEEB APTITUDE

Discriminant Analysis

	Group Means				
	GS	MD	AS	NS	F^{3}_{86}
1. SAT Verbal	59.00	53.53	54.13	55.90	2.02
2. SAT Math.	62.80	55.53	58.92	57.90	3.35*

Scaled Vector	Latent Roots	% of Discriminating Variance
1. 23	1) .1228	87%
2. 70	2) .0177	13%

Wilks' lambda = .875

$F = 1.95$ ndf$_1$ = 6

$p < .10$ ndf$_2$ = 170

Total correlation = .55

TABLE 4.10

TAT MOTIVES

Discriminant Analysis

	Group Means				
	GS	MD	AS	NS	F^{3}_{86}
1. n-achievement	17.88	15.57	16.57	17.59	---
2. n-affiliation	15.30	16.00	14.38	15.95	---
3. n-power	18.48	15.86	16.24	16.73	2.59

Latent Roots	% of Discriminating Variance
1) .101	71%
2) .034	24%
3) .007	5%

Wilks' lambda = .872

$F = 1.32$ ndf$_1$ = 9

$p > .10$ ndf$_2$ = 205

---

* Sig. at .05 level

SCHOLASTIC ABILITIES

Outside of an assorted set of scores available from the boys high school, the ability information available for the college boys consisted of the College Board (CEEB) scores on the Scholastic Aptitude Tests (SAT), both verbal and mathematical. Too much resistance would have been encountered in attempting to add an intelligence test to our extensive personality battery. As it was, these busy college volunteers spent about three or four hours in testing and interviewing. Therefore the CEEB-SAT scores seemed a reasonable compromise.

The surprising result is that there are only slight differences among these groups. The probability of these being chance differences is between .05 and .10. Similar results were attained when those going on to graduate school were compared with those that are not, and research and non-research goals were compared.

It appears as though this type of test has little bearing on the types of career decisions considered here for college science majors. Other considerations are much more relevant. These trends are so slight that prediction, using these two variables alone, is futile. Later in this chapter they will be used in combination with other information.

TABLE 4.11

THE RORSCHACH

Discriminant Analysis

	Group Means					
Factor Number	GS	MD	AS	NS	F^1_{95}	Scaled Vector
1.	-1.52	-1.94	- .73	.84	----	1.34
2.	.06	- .67	- .48	.69	----	.74
3.	.06	- .65	-1.02	.45	1.84	2.09
4.	.50	- .18	- .77	.74	2.28	1.10
5.	- .28	- .49	.18	.15	1.79	-3.15
6.	.03	- .66	.51	-.06	1.36	-2.26
7.	.54	.28	- .12	-.21	1.16	-1.86
8.	.42	- .23	.18	-.24	1.23	-6.10
9.	.12	- .30	- .02	-.33	----	-3.75
10.	- .27	.24	.18	-.08	----	-0.82
11.	.43	- .15	.30	-.36	2.20	-5.82
12.	- .21	- .12	.12	.16	----	1.31
13.	.21	- .25	.32	-.33	1.99	-3.97
14.	.04	- .49	- .12	-.12	----	-4.17
15.	.07	- .53	.16	-.02	1.59	-3.98
16.	.24	.16	- .06	-.16	----	-1.18

Latent Roots	% of Discriminating Variance
1) .41	50%
2) .22	26%
3) .20	24%

Wilks' lambda = .487

F = 1.26 ndf_1 = 48

$p < .10$ ndf_2 = 339

MOTIVES

In an attempt to assess motivation, McClelland's Test of Imagination, which is a group thematic apperception test (TAT), was used and scored for achievement, affiliation and power needs. There are apparently no significant differences among these four groups on the three variables. Only the need for power shows some promise, but even this large a difference would occur by chance more than five per cent of the time. No relevant predictions are possible with these data.

From these analyses it must be concluded that the four groups are similarly motivated, or at least any motivational differences which exist are not measured by the instrument and the resulting three scales used here.

THE RORSCHACH TEST[1]

Of the different age groups studied in this investigation, the only group for which the Rorschach test came close to being significantly related to educational decisions and career plans was the college group. Using fourteen factors derived from the forty-eight scoring categories as predictors of the four group criterion, the differences were such that the same or larger differences could have occured by chance between 5 and 10 per cent of the time. None of the F ratios for the individual factors exceeded that needed at the.05 significance level (Table 4.11).

TABLE 4.12

HIGH SCHOOL TRANSCRIPT

Discriminant Analysis

Group Means

	GS	MD	AS	NS	F^3_{90}
1. Semesters of Math.	5.60	4.80	5.77	5.61	2.01
2. Physics	.93	.67	.92	.83	2.47
3. Chemistry	.80	.80	.92	.83	---
4. Biology**	.57	.53	.38	.48	---
5. Semesters For. Lang.	7.47	9.47	6.58	5.91	3.01*
6. Semesters Non-Acad.	1.70	1.13	2.50	2.52	1.17

Scaled Vector		Latent Roots	% of Discriminating Variances
1.	2.57	1) .196	63%
2.	1.24	2) .082	26%
3.	-1.29	3) .033	11%
4.	-3.82		
5.	-6.27		
6.	1.48		

Wilks' lambda = .748

F = 1.45 ndf$_1$ = 18

p = .10 ndf$_2$ = 241

---

* Sig. at .05 level.

** Transcripts are for grade 10-12. Some students may have had biology in junior high school.

[1] Details of the manner in which this instrument was handled in this investigation can be found in Appendix E.

In Appendix E (a special section on the Rorschach Test) another college discriminant analysis is reported. This analysis was based upon plans at the time the Rorschach was administered. Those results indicate that the Rorschach test is more significantly related to current plans than to future decisions.

HIGH SCHOOL TRANSCRIPT

It seemed of interest to determine whether or not the pattern of courses selected in high school was related to college and post-college decisions. Table 4.12 reports the results of an analysis using six predictors: variables (1), (5), and (6) are the number of semesters of mathematics, foreign languages, and non-academic subjects selected, respectively; variables (2), (3) and (4) are whether or not (yes=1) physics, chemistry and biology were successfully taken in high school. For these latter three variables, the means reported in Table 4.12 are essentially the proportion of students electing to take the course, since almost no failures were reported in high school science for these college science majors, as would be expected.

TABLE 4.13

GAQ ACTIVITIES

Discriminant Analysis

	Group Means				
	GS	MD	AS	NS	F^3_{91}
1. Acad. Club Officer	1.21	1.07	1.08	1.13	---
2. Member Social Club	1.55	1.53	1.79	1.83	2.70*
3. Officer Social Club	1.36	1.47	1.46	1.35	---
4. Reading for pleasure	2.39	2.40	1.87	2.13	1.65
5. Plays	.52	.33	.42	.35	---
6. Publications	.42	.47	.37	.48	---
7. Classical Music	.58	.33	.25	.13	4.97**
8. Light Classical	.15	.33	.33	.35	1.27
9. Popular	.12	.07	.21	.30	1.56

Latent Roots	% of Discriminating Variance
1) .304	72%
2) .074	18%
3) .046	10%

Wilks' lambda = .682 $\quad$ ndf$_1$ = 27

$F = 1.26$ $\quad$ ndf$_2$ = 243

$p > .10$

---

* Sig. at .05 level

** Sig. at .01 level.

The chances are about one in ten that differences this large could arise from random samples of a common multivariate population. The main variable contributing to this very slight discrimination is the number of semesters of foreign languages elected, with the MD group highest and NS group lowest. The other three groups took more mathematics and more frequently elected physics instead of additional foreign language. Because the group trends are so slight, useful predictions are not possible for individual students.

GENERAL ACTIVITIES

The college students' initial questionnaire consisted of three parts: general activities (GAQ); home background (HBQ); and career plans. The home background data will be analyzed in the next section. The GAQ results are reported in Table 4.13. Most of the nine variables are self-explanatory. The first four involved frequency of occurance, and the last five are binary coded variables: (5) if they performed in school plays, either high school or college (yes = 1); (6) if they worked on a school publication (yes = 1); (7 - 9) type of music they preferred.

TABLE 4.14

HBQ ENVIRONMENTAL

Discriminant Analysis

Group Means

	GS	MD	AS	NS	F
1. F occup. level	3.33	3.00	3.12	3.26	---
2. Home Scale	13.94	14.47	13.75	14.87	---
3. Only Child	.12	.07	.21	.13	---
4. Oldest Child	.52	.53	.50	.87	3.26*
5. F Sci. or Tech.	.30	.00	.50	.17	4.87**
6. Lived @ home	.61	.73	.79	.91	2.45
7. Protestant	.30	.07	.42	.22	2.12
8. Catholic	.27	.27	.33	.61	2.71*
9. Jew	.27	.67	.17	.13	5.87**
10. M working	.45	.20	.37	.26	1.32

	Scaled Vectors I	Scaled Vectors II
1.	.94	.49
2.	.25	.87
3.	.08	-.31
4.	1.31	2.54
5.	-2.25	.44
6.	- .34	2.10
7.	0.27	.45
8.	1.62	1.32
9.	2.22	-2.17
10.	-1.75	.03

Latent Roots	% of Discriminating Variance
1) .375	50%
2) .269	36%
3) .104	14%

Wilks' lambda = .519

F = 2.02 ndf_1 = 30

p = .001 ndf_2 = 241

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* Sig. at .05 level.
** Sig. at .01 level.

The four groups tend not to differ on these activities variables. The overall difference is not significant at the .10 level. However, one variable produced a univariate F ratio which is significant at the .01 level, and because similar trends are found elsewhere, it is probably a reproducible trend.

The largest difference here is whether or not they preferred classical music. A majority of the science graduate students did, with only 13% of the non-science students saying yes. The NS group selected light classical (Boston "Pops"), popular, or jazz, instead. Jazz was the fourth possible choice in the forced choice question. It was deleted from the analysis to eliminate the linear restraint which would result by leaving it in. Jazz itself was similarly selected by the four groups.

HOME BACKGROUND

Ten variables of home background yielded multivariate significance at the .001 level. The univariate F ratios and scaled vectors reveal that dimensions of socio-economic status (variables 1, 2 and 10) are not relevant to this four-way decision, while family religion, ordinal position in sibship, and whether or not father is working in science &/or technology, are related (Table 4.14).

The question of sibship is very complicated and is explored further in a side investigation reported in Appendix D. Religion shows the usual trends: Catholic leave science, Protestants make up more of the applied group, Jews are highly represented in the medical professions. One dramatic trend is that none of the MD students had fathers in science and technology, while one-half of the boys in applied science did. Many of the applied group's fathers had low level jobs in technology.

A slight but interesting trend is the "living at home" variable. All of these subjects were graduates of public high schools in eastern Massachusetts so presumably could have lived at home while attending the five colleges represented here. Those going on to graduate work in science tended not to live at home during college whereas almost all of the NS group (91%) lived at home. None of these differences can be due to group differences in socio-economic status.

Although the ten variables yield significant group differences, Table 4.15 shows that the sophomore group predictions were only slightly better than chance (30% hits). A major confusion in this home background prediction was between graduate and applied science groups, because of their similarity on discriminant function I. That is, the GS and AS groups had similar means on variables: (5) father in science or technology; (9) proportion of Jews; (10) Mother working; (8) proportion of Catholics; and (4) oldest child. These are the variables highly loaded on function I.

Comparisons of the Predictor Systems

The relative significance of the nine different discriminant analyses used with the four group criterion can be seen in Table 4.16. The index to compare is the probability p. The most useful type of information seems to be the interest, temperament, and values scores of the paper and pencil inventories. Of course these may be related simply because the vocational plans which college seniors express are fairly close to what they are doing five years later, and these three tests do contain items of vocational preferences.

TABLE 4.15
HBQ DISCRIMINATIONS

Probabilities for Group Centroids

(Senior Data)

	GS	MD	AS	NS	Total
GS	.43	.07	.34	.16	1.00
MD	.34	.38	.14	.14	1.00
AS	.40	.02	.42	.16	1.00
NS	.18	.08	.17	.57	1.00

Discriminant Space

	Centroids		Variances	
	I	II	I	II
GS	.39	1.13	.138	.264
MD	.83	.93	.083	.388
AS	.24	1.30	.152	.200
NS	.65	1.66	.085	.153

Sophomore Group Predictions

	GS	MD	AS	NS	
GS	6	2	16	7	31
MD	5	6	5	7	23
AS	9	1	12	5	27
NS	4	4	12	9	29
	24	13	45	28	110

30% hits

TABLE 4.16

DISCRIMINANT ANALYSIS COMPARISONS

	Number of Variables	F	ndf_1	ndf_2	p
Interests (SVIB)	11	2.23	33	225	.0005
Values (AVL)	5	2.61	15	227	.001
Temperament (GZ)	10	2.07	30	227	.005
Ability (SAT)	2	1.95	4	170	.10
Motives (TAT)	3	1.32	9	205	>.10
Rorschach	16	1.36	48	339	.10
H.S. Transcript	6	1.45	18	241	.10
Gen. Activities (GAQ)	9	1.26	27	243	>.10
Home Background (HBQ)	10	2.02	30	241	.001

As in Chapter 3, the home background variables are also useful predictors, but here measures of socio-economic status are not doing the work, as was true in the high school to college transition. Instead, variables which may be related to personality development (especially values and interests) are the contributing factors, such as ordinal position, religion, and type (not level) of work in which father is engaged.

Approximately equally ineffective as predictors were the two projective tests, measures of ability, high school transcript information, and spare time activities during school.

TABLE 4.17

SELECTED VARIABLES

Discriminant Analysis

		Group Means				
		GS	MD	AS	NS	F^3_{77}
GZ	1. Gen. Activity	15.90	17.77	12.65	19.53	5.60**
	2. Social Interest	14.17	17.77	13.95	20.79	5.71**
AVL	3. Theoretical	56.31	53.38	49.55	48.63	8.49**
	4. Economic	34.31	34.77	39.75	39.06	2.77*
	5. Aesthetic	43.52	38.62	34.70	34.96	5.24**
SVIB	6. Professional	51.17	49.08	43.96	38.42	12.47**
	7. Technical	50.34	42.31	45.45	40.58	4.48**
	8. Prod. Mgr.	32.93	30.46	35.95	39.63	3.22*
	9. Music	44.55	43.08	37.30	35.37	3.64*
	10. Bus. Detail	18.76	23.31	29.30	29.06	7.42**
	11. Bus. Contact	28.03	33.62	32.15	37.16	5.94**
	12. Verb. Ling.	44.48	43.15	40.10	37.47	4.19**
CEEB	13. Verb.	59.52	53.46	53.70	56.11	2.46
	14. Math.	63.10	54.62	58.06	57.96	4.13**

	Scaled Vectors		
	I	II	III
1.	-10	-19	-14
2.	- 9	- 4	- 9
3.	23	-15	- 7
4.	0	- 3	5
5.	16	- 9	1
6.	- 8	46	-49
7.	16	- 3	34
8.	- 3	- 6	3
9.	9	-12	12
10.	2	36	-15
11.	-27	5	6
12.	37	2	16
13.	-15	- 1	0
14.	17	- 7	11

Latent Roots	% of Discriminating Variance
1) .810	54%
2) .394	26%
3) .309	20%

Wilks' lambda = .303

$F = 2.25$ $ndf_1 = 42$

$p < .0005$ $ndf_2 = 191$

---

* Sig. at .05 level.

** Sig. at .01 level.

The question of whether or not the several predictor systems are contributing unique information to the group separations is considered in the next section. After that, the extent to which changes in career plans are anticipated by the tests is examined.

SELECTED VARIABLES

In order to examine the discriminating information available in combinations of the different systems of data, the useful personality predictors from each instrument were analyzed together. The results are summarized in Tables 4.17 and 4.18. Three discriminant functions appear to be necessary to describe the differences among the four groups. The first function used a combination of high theoretical values and verbal-linguistic interests with low business contact interests to separate the graduate science students from the non-scientists, leaving the MD and AS groups in the middle (see Scaled Vectors and Centroids).

TABLE 4.18

SELECTED VARIABLE DISCRIMINATIONS

Probabilities for Group Centroids

(Senior Data)

	GS	MD	AS	NS
GS	.93	.02	.00	.05
MD	.20	.56	.22	.02
AS	.18	.05	.67	.10
NS	.07	.04	.04	.85

Discriminant Space

	Centroids			Variances		
	I	II	III	I	II	III
GS	52.1	- .65	-3.12	48.2	16.3	7.8
MD	43.7	2.40	-7.82	65.2	34.7	12.7
AS	43.2	4.77	-1.86	42.8	9.7	25.7
NS	35.4	-1.75	-3.00	59.6	16.3	7.0

Sophomore Group Predictions

	GS	MD	Ad	NS	
GS	18	2	6	1	27
MD	2	2	3	10	17
AS	3	1	11	7	22
NS	1	5	2	10	18
	24	10	22	28	84

50% hits

On the second function, a combination of high scores on professional worker and business detail with low scores on general activity, theoretical values, and musical interest, placed the applied science group at the top of the second discriminant axis, followed by the MD group, and with the non-science group lowest.

The third function primarily attempted to separate the MD group from the others, mostly utilizing a combination of high professional interest and low technical interest, the MD's being the only group with this combination.

The top and bottom of Table 4.18 show the extent to which group separation was accomplished. The major difficulty here was distinguishing the MD and non-science groups. Over half of the sohpomores in the MD group were assigned to the non-science group. If the MD and NS groups were combined, it looks as though over two-thirds of the sophomores would be correctly classified, instead of the 50% hit rate obtained here.

All four of the instruments represented here appear to be contributing some unique information to the prediction, as revealed by the high loading on at least one of the functions for most of the predictors. Only two of the variables have near-zero loadings on all three functions, economic values and production manager interests.

TABLE 4.19

SIGNIFICANT VARIABLE

Discriminant Analysis (16:16 4 Group)

	Group Means				
	GS	MD	AS	NS	F^3_{77}
1. Gen. Act.	15.03	18.50	15.35	18.89	2.10
2. Social Interest	14.07	18.56	16.15	19.67	2.64
3. Theoretical	55.00	53.50	49.88	48.78	4.22**
4. Economic	34.80	34.38	38.73	42.56	3.42*
5. Aesthetic	40.90	38.69	38.65	30.11	3.13*
6. Professional	50.30	47.50	42.96	38.33	7.00**
7. Technical	48.07	41.06	48.27	37.33	4.65**
8. Prod. Mgr.	31.50	30.81	40.69	36.33	6.65**
9. Music	45.70	43.75	34.35	34.00	7.67**
10. Business Detail	20.23	24.00	28.12	29.22	3.96*
11. Business Contact	28.77	35.00	31.42	39.89	6.17**
12. Verb. Ling.	44.20	43.38	38.00	39.67	4.06*
13. Verbal	59.20	54.56	53.73	57.22	2.16
14. Math.	61.37	55.69	58.81	60.11	1.72

Latent Roots	% of Discriminating Variance
1) .693	51%
2) .471	34%
3) .206	15%

Wilks' lambda = 2.04

$F = 2.04$ $ndf_1 = 42$

$p < .005$ $ndf_2 = 191$

* Sig. at .05 level.
** Sig. at .01 level.

TABLE 4.20

SCIENCE MAJOR GROUP MEANS

Variable	Biology (N=48)	Engi-neering (N=33)	Chemis-try (N=38)	Geology (N=14)	Physics (N=61)	F Ratios ndf= 4 & 189
Guilford-Zimmerman Temperament						
1. Activity	18.17	16.00	15.95	16.64	15.41	1.79
2. Restraint	17.29	17.58	18.61	18.64	18.03	---
3. Ascendance	17.83	14.67	15.58	16.64	15.07	2.36
4. Sociability	20.27	16.82	16.66	16.14	15.36	3.62
5. Stability	17.92	18.03	17.39	16.79	17.39	---
6. Objectivity	18.69	19.48	17.97	18.71	19.46	---
7. Friendliness	14.08	13.88	14.97	12.14	15.33	1.39
8. Thoughtfulness	19.98	19.42	20.74	21.29	21.08	---
9. Per. Relations	17.04	18.33	16.42	15.86	15.70	1.43
10. Masculinity	20.13	20.94	21.16	21.86	20.07	1.08
Allport-Vernon-Lindzey Values						
11. Theoretical	51.27	48.64	53.53	51.86	54.74	4.82
12. Economic	36.38	43.67	38.53	40.57	37.20	4.97
13. Aesthetic	37.13	34.61	35.24	37.07	39.31	1.91
14. Social	36.04	33.24	33.32	29.86	32.64	2.56
15. Political	40.46	41.45	40.18	44.00	38.41	2.79
Religious*	38.85	38.61	39.39	36.86	37.84	---
Strong Vocational Interests						
16. Prof. Worker	44.46	39.27	45.84	45.07	49.30	6.42
17. Tech. Worker	41.73	47.30	48.42	49.21	50.44	5.10
18. Prod. Mgr.	35.02	44.03	36.92	39.71	35.30	6.64
19. Active Worker	37.65	42.33	38.21	43.71	36.79	2.10
20. Welfare Worker	42.81	33.33	35.68	35.57	36.54	6.98
21. Musical	39.50	33.61	39.37	36.64	42.93	4.25
22. CPA Partner	27.71	26.67	31.26	25.07	32.39	4.37
23. Business Detail	24.79	32.79	27.87	24.21	22.16	6.53
24. Bus. Contact	33.84	32.76	30.97	28.43	27.66	4.46
25. Verb.-Linguistic	38.52	35.00	39.29	37.14	41.43	4.31
26. President Mfg.	29.44	35.55	31.79	28.64	29.84	3.78
TAT Motives						
27. n-Achievement	16.75	17.00	16.76	17.50	15.77	---
28. n-Affiliation	17.04	15.33	14.92	15.36	15.13	2.21
29. n-Power	15.81	16.82	17.11	17.14	17.33	1.48

Wilks' lambda = .318

$F = 1.85$ $ndf_1 = 116$

$p < .0005$ $ndf_2 = 642$

* Religious scale was deleted from the discriminant analysis because of the linear restraint among the six AVL scales.

Prediction of Migrations

One way to show that the measurements made at grade 16 are more related to grade 20 career decisions than to grade 16 plans is to compare the separations produced at the two grades. If the F ratios increase from grade 16 to 20, it suggests that individuals are migrating to groups which they more nearly resemble. Thus their eventual decisions are more consistent with their measured attributes than were their plans.

Table 4.19 reports the results of a discriminant analysis based on grade 16 plans. This should be compared to Table 4.17, where actual decisions as of grade 20 served to define group membership. Since the number of degrees of freedom are the same in both cases, the F ratios are directly comparable. The F ratio based upon the Wilks' lambda criterion went from 2.04 at grade 16 to 2.25 at grade 20, so at least the overall differences among the groups is increasing.

Nine of the fourteen univariate F ratios increased. Where they did not increase, they remained essentially the same. The SVIB scales for production manager and musical performer were the only two exceptions. But even for production manager, the changes in the means make sense. The mean for the AS group went down from 40.69 to 35.95, while the NS group (into which production managers are classified) went from 36.33 to 39.63. The GS and MD means remained about the same. Thus those in the AS group with high production manager scores migrated to the NS group over the five year period.

From these results it appears safe to conclude that changes in plans are anticipated by these personality measures.

Distinguishing Among College Science Majors

Tables 4.1 and 4.2 previously have shown the relationships between membership in the four criterion groups used in the above analyses and college major. Because of the high dependencies between the two classification schemes, the next step was to determine the personality differences existing among the college major groups, and compare them to the differences among the four groups.

The variables used in this analysis assessed student interests (Strong Vocational Interest Blank - SVIB), temperament (Guilford-Zimmerman Temperament Survey - GZ), values (Alport-Vernon-Lindzey Study of Values - AVL), and motives (McClelland's Test of Imagination - TAT). The boys were classified by college major at either grade 14 or 16. The five criterion groups decided upon were: biology, engineering, chemistry, geology and physics. The few mathematics students were included in the physics group, the group they most nearly resembled. The thirty scales which these four instruments yield are listed in Table 4.20 together with the thirty means for each of the five groups and the univariate F ratios (N = 194).

Tables 4.21 and 4.22 present the rest of the results of the discriminant analysis. Essentially all of the information regarding group differences which was contained in the original thirty variables is preserved in the four resulting discriminant functions, and most (91%) is contained in the first three functions. The probability that these five groups are random samples from a common multivariate population is less than .0005. Therefore, the groups have definite over-all differences on the thirty variables.

Although statistical significance is important, it is the nature of the separation which is interesting. The most useful instrument within the battery was the Strong interest test. Ten of these eleven scales had significant univariate F ratios at the .01 level. The following outline summarizes the most pronounced differences on the individual variables.

	High Group	Low Group
Welfare Worker	Biology	Engineers
Business Detail	Engineers	Physicists
Production Mgr.	Engineers	Biologists
Professional Worker	Physicists	Engineers
Technical Worker	Physical Sciences	Engineers

TABLE 4.21

SCIENCE MAJOR DISCRIMINANT ANALYSIS

Latent Roots and Vectors

Root Number	I	II	III
Latent Root	.736	.363	.186
% of Discriminating Variance	52%	26%	13%

Variable	Corresponding Vector		
1. Activity	12	2	- 5
2. Restraint	3	18	-12
3. Ascendance	10	-21	2
4. Sociability	17	15	- 9
5. Stability	-10	- 4	6
6. Objectivity	- 4	- 9	-13
7. Friendliness	6	-22	12
8. Thoughtfulness	- 9	- 3	- 2
9. Per. Relations	1	20	6
10. Masculinity	- 4	12	13
11. Theoretical	1	- 3	11
12. Economic	0	14	-19
13. Aesthetic	- 3	32	- 4
14. Social	5	19	7
15. Political	4	24	- 1
16. Prof. Worker	91	16	21
17. Tech. Worker	-28	-59	49
18. Prod. Mgr.	-12	22	-41
19. Active Worker	10	19	- 9
20. Welfare Worker	23	- 6	15
21. Musical	-56	- 1	13
22. CPA Partner	13	-20	- 6
23. Business Detail	1	-11	61
24. Bus. Contact	13	- 5	45
25. Verb.-Linguistic	-20	-21	-27
26. President Mfg.	-15	21	20
27. n-Achievement	5	10	1
28. n-Affiliation	3	2	- 5
29. n-Power	- 9	- 6	- 3

The most useful scales on the AVL values test were theoretical and economic values, the engineers being the lowest group on theoretical and highest on economic. None of the TAT motives scores were significant and on the G-Z temperament test, only the sociability scale was significant, the biology majors being highest.

Loadings for the three discriminant functions are in Table 4.21. The first function primarily used patterns of interest (as outlined above) to separate the biologists (high) and engineers (low), leaving the three groups of physical scientists completely overlapping in the middle (see centroids Table 4.22). The second function was most useful in separating out the physics group, and the third function, the geologists.

Comparisons of the F ratios found here with those resulting from the previous four group criterion reveals that the college major criterion produces about as large a difference among groups relative to within group variation as does the four group criterion. However, the latter is more interesting because those four groups are more relevant to the types of decisions which are made by science majors following college

TABLE 4.22

COLLEGE MAJOR DISCRIMINATIONS

Predictor Classifications

		Biology	Engineering	Chemistry	Geology	Physics	
College Major	Biology	35	2	3	2	6	48
	Eng.	2	20	2	3	6	33
	Chem.	3	2	19	2	12	38
	Geol.	1	1	1	8	3	14
	Physics	8	2	3	2	46	61
		49	27	28	17	73	194

66% hits

Probabilities of the Centroids

		Biology	Engineering	Chemistry	Geology	Physics	
College Major	Biology	.70	.04	.10	.00	.16	1.00
	Eng.	.02	.66	.18	.03	.11	1.00
	Chem.	.07	.08	.46	.05	.34	1.00
	Geol.	.07	.13	.03	.58	.19	1.00
	Physics	.05	.04	.23	.04	.64	1.00

Discriminant Space

	Centroids			Variances		
	I	II	III	I	II	III
Biology	18	22	33	6.5	28	7.8
Eng.	11	34	33	11.2	18	9.6
Chem.	14	19	34	8.1	25	9.9
Geol.	14	22	29	2.3	21	9.2
Physics	14	16	32	8.7	20	9.1

graduation. Also, it could be argued that the differences among college major groups are simply a function of their compositions of the four criterion groups, since the nature and extent of the differences in Table 4.20 are related to the composition of the groups as shown in Tables 4.1 and 4.2. When comparing the F ratios for Table 4.20 with those in Table 4.17 the differences in the number of degrees of freedom should be kept in mind. For the four group case, an F of 2.71 is needed at the .05 level, whereas an F of 2.42 is all that is needed for the five group case.

COLLEGE DIFFERENCES

Because the colleges differed in the number of students in the various criterion groups, it seemed desirable to examine the extent to which colleges differed relative to the previously examined criterion groups. This was done separately for sophomore and senior groups.

The results for the overall differences among the six colleges on the twenty-nine variables are summarized in Table 4.23. There are only slight differences among the colleges for the sophomore group, with slightly greater differences for the seniors.

TABLE 4.23

COMPARISONS OF COLLEGE DISCRIMINANT ANALYSES

	Wilks' Lambda	ndf$_1$	ndf$_2$	F	p
College Differences (Soph. group) N = 105 G = 6	.111	145	354	1.27	.03
College Differences (Senior group) N = 8[illegible] G = 6	.048	145	277	1.62	.001

TABLE 4.24

COMPARISONS OF COLLEGE MEANS

			College Group Means					
Variable	Grade	F	B.C.	B.U.	M.I.T.	N.U.	T.U.	H.U.
(13) Aesthetic	14	2.12	33.8	39.7	36.5	33.3	33.7	39.4
Values	16	4.45	32.3	36.3	41.4	37.0	36.5	45.7
(16) Professional	14	2.79	43.1	48.7	50.9	41.1	41.7	43.7
Worker	16	4.08	41.6	47.1	49.2	38.7	45.3	51.2
(18) Production	14	2.62	39.1	38.6	37.3	46.7	39.0	36.4
Manager	16	3.48	36.3	34.9	29.7	42.2	37.9	31.8
(25) Verbal-	14	1.83	36.6	38.7	39.5	33.3	35.1	37.5
Linguistic	16	4.01	37.3	43.0	44.7	36.2	39.5	44.9

However, since these particular results are based upon cross-sectional rather than longitudinal data, it cannot be definitely said whether or not the greater differences among the older groups are due to institutional press[1], or whether it is because certain types of students drop out of certain types of institutions.

Further consideration, however, indicates that it may be institutional press more than the latter. For one thing, the nature of the senior differences reflected the type of college program the student was exposed to, either highly technical or liberal arts. Table 4.24 reports the means of the six colleges, both sophomores and seniors, for variables which were significant at the .01 level in the senior group.

The important point here, however, is that the differences among the colleges were less than the differences among the four criterion groups. This is important to check since the colleges contributed varying proportions to the composition of the four groups. Thus the differences among the four post-college decision groups are not simply a result of the fact that post-college decisions are related to the undergraduate college attended.

---

[1] Modification of personality due to college environment.

TABLE 5.1

GRADE 5 SELF-PREDICTIONS

		Group Membership at Grade 5			
		PSP	NS		
Grade 6 Classification	PSP	34	21	55	77% hits
	NS	11	75	86	
		45	96	141	
Grade 7 Classification	PSP	35	33	68	70% hits
	NS	10	63	73	
		45	96	141	
Grade 8 Classification	PSP	31	31	62	68% hits
	NS	14	65	79	
		45	96	141	
Grade 9 Classification	PSP	29	28	57	52% hits
	CNS	8	45	53	
	NCT	8	23	31	
		45	96	141	

TABLE 5.2

PSP MEMBERSHIP, GRADES 5 to 9*

	Grade					
	5	6	7	8	9	Number of Students
PSP from 5 to 9	1	1	1	1	1	23
Movement Into PSP	0	1	1	1	1	10
	0	0	1	1	1	8
	0	0	0	1	1	3
	0	0	0	0	1	3
Movement Out of PSP	1	0	0	0	0	4
	1	1	0	0	0	5
	1	1	1	0	0	4
	1	1	1	1	0	1
Never in PSP	0	0	0	0	0	46
	Various patterns of zeros and ones ending in one.					10
	Various patterns of zeros and ones ending in zero.					24

---

* Coded 1=PSP
0=Non-science

CHAPTER 5

THE PRE-HIGH SCHOOL AND HIGH SCHOOL YEARS

The group of eleventh graders selected for study was useful in examining the educational and career decisions as students moved from high school to college for boys who took the college preparatory curriculum in high school. Also of interest is the choice of college preparatory curriculum in the first place, and the nature and extent of science career plans prior to high school and as the student moves into and through high school.

Two different age groups were selected for these purposes. One group consisted of fifth grade boys, going through to grade 9 during the five years of the study. The other was a group of eighth grade boys, who ended up as high school seniors after five years. All boys in both groups were above average on general intelligence tests according to school records available at the time of selection for participation in this investigation. Within this group lies the Potential Scientist Pool (PSP).

At the early age of ten, the PSP consists of those boys with above average intelligence who plan careers in science and technology, the plans requiring at least a four-year college science or engineering major. At grade 5, 32% have such plans (Table 5.1). At this early stage of development the PSP actually increases, going to 39% at grade 6, and up to 48% at grade 7. Then at grade 8 the "tide changes", and from eighth grade through graduate school, movement out of the PSP is greater than the movement in. In fact, in Chapter 3 it was noted that after grade 12 the movement into the PSP is essentially non-existent.

Specific career plan patterns over these early five years can be seen in Table 5.2. Twenty-three boys (16%) expressed science career plans every time they were contacted during the five year period. Twice as many (32%) showed no interest in a scientific career. Movement into the PSP dropped off after Grade 7. There seemed to be much instability in career plans, with one-fourth of the students moving back and forth between PSP and non-PSP during the five years. Changes in plans are much more frequent than that figure suggests when specific plans are examined.

Most of the increase in the PSP during grades 5, 6 and 7 are the result of changes from what might be called "fantasy" goals, such as cowboy, fireman, and policeman, or changes from essentially no goal at all. After grade 7 most boys will tell you at least something when they are asked what they want to become. Those few who gave no indication of plans during this early period were classified in the non-science group.

The sizes of the criterion groups for grades 8 to 12 are summarized in Table 5.3. For this sample, the size of the PSP held constant for grades 8 and 9 at 49%, with about as many immigrants (14) as emigrants (13). This is slightly higher than the proportions of the previous sample at these same grades, 44% and 40%. The percentage of PSP's was in the fourties for grades 10 and 11, and then a sharp drop occured between grades 11 and 12, where the percentage went to 27%.

Specific career plan patterns during grades 8 to 12 reported in Table 5.4 resemble the 5 to 9 patterns of Table 5.2. The proportions of boys staying in the PSP all five years and those never in the PSP during the five years were the same as in the younger group.

TABLE 5.3

GRADE 8 SELF-PREDICTIONS

		Group Membership at Grade 8				
		PSP	CNS	NCT		
Grade 9 Classification	PSP	68	10	3	81	74% hits
	CNS	7	32	8	47	
	NCT	7	7	23	37	
		82	49	34	165	
Grade 10 Classification	PSP	54	11	7	72	64% hits
	CNS	19	31	7	36	
	NCT	9	7	20	57	
		82	49	34	165	
Grade 11 Classification	PSP	50	8	10	68	62% hits
	CNS	22	32	4	58	
	NCT	9	8	20	37	
	NCNT	1	1	0	2	
		82	49	34	165	
Grade 12 Classification	PSP	28	9	7	44	45% hits
	CNS	34	25	5	64	
	NCT	16	8	22	46	
	NCNT	4	7	0	11	
		82	49	34	165	

TABLE 5.4

PSP MEMBERSHIP, GRADES 8 to 12

	8	9	10	11	12		
PSP 8 to 12	1	1	1	1	1	23	23
Movement Out of PSP	1	1	1	1	0	13	39
	1	1	1	0	0	8	
	1	1	0	0	0	10	
	1	0	0	0	0	8	
Movement Into PSP	0	1	1	1	1	2	9
	0	0	1	1	1	2	
	0	0	0	1	1	3	
	0	0	0	0	1	2	
Never In PSP	0	0	0	0	0	45	45
Various patterns of zeros and ones ending in zero.							23
Various patterns of zeros and ones ending in one.							11
							150

15% and 30% respectively. The difference here was that the movement into the PSP was reduced to two or three boys a year, and movement out was higher, at eight to thirteen boys per year. The back and forth movement remained about the same, however.

After grade 5 and prior to grade 8, very few boys expressed career plans which did not include a college education. This is not to say that all had specific college plans, but rahter the goals they expressed would required a college education (lawyer, engineer, doctor, architect, etc.). For this reason, a two group criterion, PSP or not, seemed to make sense for these early years. About grade 8 a new category appeared in significant numbers, technical workers not requiring college (mechanic, electrician, draftsman, army technician, business machine operator, etc.). This occured at the same time the student had to make his first major school decision, college preparation or not.

The fourth criterion category which was used in the high-school-to-college analyses of Chapter 3 was not needed in the 8 to 12 analyses until grade 12. This was the non-college non-technical (NCNT) worker category (accountant, sales, army officer, state policeman). At grade 11 only one boy expressed such a plan, and at grade 12 there were 9. Although this NCNT group was small at grade 12, the group was included in the discriminant analyses so that the trends could be compared to those reported in Chapter 3.

The next section of this chapter reports the discriminant analyses of the 5 to 9 group, using grade 9 career goals as the criterion college-science (PSP), college-non science (CNS), and non-college technical worker (NCT).

This is followed by the analyses of the 8 to 12 group, using the grade 12 four-group criterion.

Grades 5 To 9 Discriminant Analyses

SUMMARY

The main conclusion which can be drawn from the following set of analyses is that neither behavioral measures available in elementary school nor environmental conditions seem to be able to anticipate whether a ninth grade student will: (1) plan a career in science (PSP), (2) plan college and not science (CNS) or (3) not plan college and intend to become a technical worker (NCT).

An ability difference was observed between the two groups planning college and the non-college boys as was expected, but it was much smaller than expected. The only variable significant at the .01 level was the parents estimate of how far they expect their son will go in his education. On this variable, the PSP was highest, followed by the CNS group, with the NCT group lowest.

The details of these results can be found in the following tables and discussions.

DETAILS OF THE DISCRIMINANT ANALYSES

SCHOLASTIC ABILITY

Ability information was obtain[illegible] grades 5, 6 and 8 for this sample. The grade in which the test was administered is recorded after the name of the test in Table 5.5. The criterion groupings were based upon career plans as of grade 9. Only very slight differences were revealed by the multivariate test of significance (p = .10). The interesting trend here was the shift in the ranking of the means. At grade 5 the college-

TABLE 5.5

ABILITIES DISCRIMINANT ANALYSES

	Grade Administered	Group Means			
		PSP	CNS	NCT	F^2_{117}
1. STEP Science	5	23.96	24.61	20.79	3.06
2. STEP Math.	5	16.00	17.16	14.50	4.06 *
3. STEP Reading	5	22.73	22.32	21.00	1.31
4. Otis	6	53.52	51.64	47.43	3.30 *
5. STEP Math.	8	16.23	15.36	14.61	1.57
6. STEP Science	8	20.88	19.32	18.04	3.61 *

Latent Roots	% of Discriminating Variance
1) .095	56%
2) .075	44%

Wilks' lambda = .850

F = 1.586 ndf$_1$ = 12

p = .10 ndf$_2$ = 224

TABLE 5.6

SCIENCE ACTIVITIES DISCRIMINANT ANALYSIS

	Group Means			
Factor	PSP	CNS	NCT	F^2_{138}
1. General	41.72	38.83	45.55	---
2. Woodsy-Birdsy	27.54	27.43	33.94	1.21
3. Tinkerer	16.46	15.57	22.06	2.94
4. Thinker	25.14	23.21	25.48	---

Latent Roots	% of Discriminating Variance
1) .109	95%
2) .005	5%

Wilks' lambda = .896

F = 1.90 ndf$_1$ = 8

p = .05 ndf$_2$ = 270

---

* Significant at .05 level.

nonscience boys has a slight edge over the PSP on the science and mathematics STEP tests, whereas by grade 8 the trend had reversed. Of course it is not possible to conclude from this that the PSP improved its abilities relative to the non-science group, because of a career interest. Also, speculations such as these may be idle because the trend is so slight it may not be consistently reproducible. However, it is sufficiently interesting to warrant further investigation.

The important finding here is that ability, at this stage of development as defined by these six measures, appears not to be a significant determinant of career plans, when career plans are classified in this fashion.

MANIFEST SCIENCE INTERESTS

A locally developed science activities inventory was administered to these boys at grade 5.[1] This attempted to measure the extent to which students voluntarily participated in science type activities, in and out of school. The instrument was studied extensively in another investigation (see Cooley and Reed, 1961), and four factors were derived: 1) a general science interest; 2) a "wooday-birday" biological interest; 3) a "tinkerer" mechanical interest; 4) a "thinking about things" theoretical interest.

TABLE 5.7

"PERSONALITY" DISCRIMINANT ANALYSIS

(Grade 6 Administration)

	Group Means			
	PSP	CNS	NCT	F^{2}_{127}
1. Sociable	4.72	4.90	4.78	---
2. Verbal Ability	7.23	7.40	6.59	2.68
3. Emotionally Mature	5.43	5.54	5.37	---
4. Unrestrained	5.30	5.38	5.22	---
5. Aggressive	5.06	5.18	4.96	---
6. Enthusiastic	5.49	5.44	5.19	---
7. Conscientious	6.47	6.54	5.96	1.48
8. Adventurous	4.98	5.22	5.04	---
9. Sensitive	3.49	3.76	3.26	---
10. Individualistic	6.32	5.42	5.67	4.32 *
11. Worrying	4.98	4.84	4.96	---
12. Self-Sufficient	6.04	5.84	6.15	---
13. Self-Controlled	4.49	4.46	4.26	---
14. Tense	4.15	4.22	3.89	---

Latent Roots	% of Discriminating Variance
1) .127	61%
2) .082	39%

Wilks' lambda = .820 $\quad$ ndf$_1$ = 28

F = .848 $\quad$ ndf$_2$ = 228

---

[1] Reed Activities Inventory (mimeographed). Copies available from the principal investigator upon request.

* Signif. at the .025 level.

The surprising result of the discriminant analysis using these four factors as predictors of grade 9 plans is that only a slight relationship exists (probability less than .10). The one factor which approached the .05 level of significance was the tinkerer factor, with the technical worker group being high, with the PSP being only slighly higher than the non-science group. Thus once again the "randomness" of the career development of boys in late elementary and junior high school is seen, at least in so far as the predictability of plans are concerned. Boys who manifest a science interest at grade 5 may or may not be considering careers in science at junior high school. The results of this discriminant analysis are reported in Table 5.6.

"PERSONALITY" QUESTIONNAIRE

A group test of non-intellective personality factors administered to this group was the High School Personality Questionnaire (HSPQ) of the Institute for Personality and Aptitude Testing. This was designed to be appropriate for ages 12 to 17 and was administeres to this sample at grades 6 and 8. Using career plans at grade 9, neither administrations produced scores related to group membership, as can be seen in Tables 5.7 and 5.8. Grade 8 scores were slightly more related to grade 9 plans (or

TABLE 5.8

"PERSONALITY" DISCRIMINANT ANALYSIS

(Grade 8 Administration)

	Group Means			
	PSP	CNS	NCT	F^2_{118}
1. Sociable	5.06	5.11	4.93	---
2. Verbal Ability	7.94	7.91	7.82	---
3. Emotionally Mature	5.14	5.41	5.29	---
4. Unrestrained	5.76	5.52	5.07	1.25
5. Aggressive	5.80	5.89	5.93	---
6. Enthusiastic	5.08	5.86	4.93	4.02 *
7. Conscientious	5.86	5.77	5.32	1.03
8. Adventurous	4.80	5.25	4.68	---
9. Sensitive	3.04	2.73	2.18	2.44
10. Individualistic	6.12	5.48	5.75	1.87
11. Worrying	5.02	4.66	4.96	---
12. Self-Sufficient	6.61	5.75	5.93	3.79 *
13. Self-Controlled	4.14	3.75	3.86	---
14. Tense	4.63	4.43	4.18	---

Latent Roots	% of Discriminating Variance
1) .146	57%
2) .111	43%

Wilks' lambda = .786 ndf_1 = 28

F = .961 ndf_2 = 210

---

* Signif. at the .05 level.

rather were slightly less non-significant) than were those from grade 6. The slight trends produced here will be considered in a special section on the HSPQ in the discussion of the 8 to 12 analyses.

What can be said at this point is that the attributes which this test measures are unrelated to career plans at this early stage of development.

THE RORSCHACH TEST

The fourteen principal components scores of forty-three Rorschach scoring categories were unable to distinguish among these three criterion groups. The F ratio corresponding to the resulting Wilks' lambda was less than one. Individually, none of the factors came even close to statistical significance. Since most of the reliable variance in the original Rorschach scores is preserved by the factor scores (70% of the total variance was accounted for), it can safely be said that whatever it is the Rorschach is measuring at fifth grade, it is unrelated to the career plans of ninth grade boys. It was also unrelated to fifth grade plans.

TABLE 5.9

ENVIRONMENT DISCRIMINANT ANALYSIS

	Group Means			
	PSP	CNS	NCT	F^2_{137}
1. F. Education	5.09	5.08	4.61	---
2. M. Education	4.86	4.60	4.55	---
3. F. Occup. Level	3.33	3.21	3.45	---
4. M. Working	2.60	2.62	2.32	1.78
5. F. Social Evenings	1.04	1.44	.94	2.68
6. M. Social Evenings	.88	1.10	.84	1.25
7. Orderliness	2.28	2.31	2.10	---
8. Chores (PQ)	1.98	2.25	2.03	1.18
9. Chore Attitudes	2.91	3.00	3.06	---
10. Gets Along Well	1.82	1.77	1.84	---
11. Likes School Work	1.89	1.79	1.87	---
12. FM Aspiration	4.42	4.27	4.03	3.20 *
13. FM Expectation	4.05	3.71	3.42	5.88 **
14. Oldest Child	.42	.33	.19	2.37
15. F. Science Hobby	.49	.31	.35	2.06
16. Broken - Home	.12	.17	.03	1.81
17. F. Reinforces Science	2.74	2.52	2.42	---
18. Other Male Reinf. Sci.	1.30	1.56	1.68	---
19. Chores	10.26	10.29	12.74	1.47
20. Home Scale	13.40	14.33	13.03	1.85

Latent Roots	% of Discriminating Variance
1) .265	63%
2) .153	37%

Wilks' lambda = .686 ndf $_1$ = 40

F = 1.22 ndf $_1$ = 236

$p > .10$

Several attempts were also made to use this instrument as it was originally intended to be used. Clinical interpretations of the protocals yielded no information relevant to career plans. Although these inquiries were conducted rather unsystematically by graduate students who wanted to "save the phenomena", their lack of success was sufficiently convincing to this investigator to make further probing along clinical lines seem unprofitable.

As the grades 8 to 12 Rorschach results were equally insignificant, they are not reported in the next section. It need only be reported that the results could not be considered different from those which would result from an analysis of random numbers.

ENVIRONMENT

Twenty environmental variables proved to yield only two trends which are significant at the .05 level. The environmental system as a whole was not significant, but the trends observed here for the two "significant" predictors, parental aspirations and expectations for son's education, make sense in terms of the environmental results from the other age groups (Table 5.9).

One important finding here is that variables of socio-economic status (variables 1, 2, 3, 4 and 20) are not related to membership in the three criterion groups. Family status appears not to be involved at this early stage of development, not even when college or not is a consideration. At least this is the case for these boys with above average general intelligence.

TABLE 5.10

ABILITIES DISCRIMINANT ANALYSIS

(Grade 12 Plans)

	Grade Administered	Group Means PSP	CNS	NCT	NCNT	F^{3}_{145}
1. Otis	9	69.36	67.64	60.73	61.64	12.09 *
2. STEP Math.	8	17.07	16.65	13.17	13.55	11.75 *
3. STEP Science	8	22.50	20.58	18.15	16.82	10.28 *
4. STEP Reading	8	23.00	23.20	18.78	19.55	10.78 *

Scaled Vectors I	II
1. 29.22	2.95
2. 31.66	-10.07
3. 20.85	39.15
4. 20.84	-29.51

Latent Roots		% of Discriminating Variance
1)	.36	86%
2)	.06	14%

Wilks' lambda = .692

F = 4.67 ndf $_1$ = 12

$p < .0005$ ndf $_2$ = 376

---

* Significant at the .0005 level.

A slight trend is observed in the two variables ⑤ and ⑥ which concerned the number of social evenings the parents spent away from home. The non-science group have slightly more sociable parents than either of the two science-technology groups. The trend has a high probability of occurring by chance, however. In fact the only sure trend is that parents of the two college groups want and expect higher educational attainments of their sons, with the PSP being slightly higher than the college-nonscience group. This difference is not explained by the socio-economic status of the home.

Grades 8 to 12 Discriminant Analysis

In this series of analyses a four group criterion was used, based upon educational and career plans as of the spring of their senior year. The groups are defined in the same manner as those used in Chapter 3.

1. PSP: Boys planning college with the intent of majoring in a science or engineering, with career plans consistent with this intention.
2. CNS: Boys planning college with no intention of pursuing careers in science and technology.
3. NCT: Non-college boys with plans to work in technology with some post-college schooling possible but only for one or two years.
4. NCNT: Non-college boys with no plans to work directly in technology.

TABLE 5.11

ABILITIES DISCRIMINATIONS

Predictor Classifications

	PSP	CNS	NCT	NCNT	
PSP	19	15	8	0	42
CNS	15	32	8	0	55
NCT	4	12	25	0	41
NCNT	1	3	5	2	11
	39	62	46	2	149

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT
PSP	.37	.43	.17	.03
CNS	.30	.49	.17	.04
NCT	.17	.27	.48	.08
NCNT	.15	.33	.43	.09

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	54.28	2.80	42.22	9.61
CNS	52.66	1.22	33.51	10.79
NCT	45.01	2.42	59.11	7.15
NCNT	45.34	.89	70.55	13.70

SUMMARY

The main conclusion which can be drawn from the following discriminant analyses is that by the time the boys reach grade 12, career plan groups are clearly distinguishable. The differences among these four groups are very similar in kind to those found for the Chapter 3 criterion based upon grade 14 plans. Wherever the similarity does break down, the differences are simply not of the same degree at grade 12 as they are at grade 14, since actual post-high school behavior is not always the same as plans as of late in grade 12.

DETAILS OF THE DISCRIMINANT ANALYSES

ABILITY

These four groups of high school seniors differ very significantly (beyond the .0005 level) on school abilities as measured by the four tests listed in Table 5.10. The discriminant space centroids show that the two college groups are far more able than the two non-college groups, with the PSP slightly higher than the non-science college group. At this stage ability has become much more important than it was for junior high school plans. Also, it should be pointed out that the differences between the college and non-college groups are greater here than they were for the college preparatory students studied in Chapter 3. This may be due in part to the fact that the grade 11 sample had passed through that additional screening (choice of college preparatory curriculum) and thus the students deciding not to go to college at the end of high school

TABLE 5.12

ABILITIES DISCRIMINANT ANALYSIS

	Group Means				
	PSP	CNS	NCT	NCNT	F^3_{123}
1. Spatial	23.61	22.64	22.26	23.78	
2. Logical	23.26	23.12	21.80	22.22	1.79
3. Numerical	16.26	16.80	14.18	15.44	2.44
4. Verbal	22.97	23.31	16.66	18.67	10.49 *
5. Total Language	44.74	45.20	36.58	36.78	9.15 *
6. Total Non-Lang.	41.67	40.86	38.45	40.56	1.98
7. Class rank	57.23	53.92	44.11	42.78	16.16 *

Scaled Vectors

	I	II
1.	-18.65	- 7.99
2.	- 7.83	- 8.30
3.	-27.83	-26.48
4.	19.98	-39.98
5.	6.48	42.50
6.	34.08	17.08
7.	38.35	7.68

Latent Roots		% of Discriminating Variance
1)	.56	89%
2)	.06	8%
3)	.02	3%

Wilks' lambda = .600

$F = 3.12$ $ndf_1 = 21$

$p < .0005$ $ndf_2 = 336$

---

* Significant at the .0005 level.

were a more able group than were the 8 to 12 non-college students, which contained some students who did not select the college preparatory curriculum. Another reason for the lack of difference between college non-science and the two non-college groups in chapter 3 is the migrations among groups which occured after high school graduation, the chapter 3 results being based upon grade 14 plans rather than grade 12, as was the case here.

An interesting trend is indicated by the second discriminant function. The centroids place the PSP and NCT groups high, with the two non-science technology groups low. This was accomplished by heavily weighting the STEP Science test and suppressing the others with negative or near-zero weights (see scaled vector II). This seems to indicate that ability is a consideration in choosing among the non-college alternatives.

Tables 5.12 and 5.13 report a second ability discriminant analysis using scores from the California Test of Mental Maturity (CMM) at grade 11 and high school class rank as predictors. Again the superiority of the two college bound groups is clearly evident, with the PSP having a slight edge over the non-science college group. Also, the slight second function, placing PSP and NCT close together, was repeated in this result. However, the scaled vectors in this analysis are uninterpretable because of the linear restraint present among combinations of the CMM scales used here.

TABLE 5.13

ABILITIES DISCRIMINATIONS

Predictor Classifications

		PSP	CNS	NCT	NCNT	
Grade 12 Group Membership	PSP	9	19	3	0	31
	CNS	7	31	11	0	49
	NCT	1	10	27	0	38
	NCNT	0	2	4	3	9
		17	62	45	3	127

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT
PSP	.40	.49	.11	.00
CNS	.29	.58	.12	.01
NCT	.09	.32	.48	.11
NCNT	.08	.29	.48	.15

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	28.89	3.05	13.80	1.47
CNS	27.38	2.47	15.99	1.31
NCT	21.81	2.93	23.40	1.73
NCNT	21.75	2.18	6.83	5.60

"PERSONALITY" QUESTIONNAIRE

Two discriminant analyses were conducted using the "High School Personality Questionnaire" (HSPQ), one based upon plans at the time the questionnaire was administered (grade 9), the other on grade 12 plans. The results are reported in Tables 5.14 to 5.17. In both analyses the overall results are significant at the .025 level.

Although the differences among the criterion groups produced by the HSPQ are too slight to serve as useful predictors, a few of the trends are revealing and need to be considered in detail. This discussion will include the consideration of the trends

TABLE 5.14

"PERSONALITY" DISCRIMINANT ANALYSES

(Grade 9 Plans)

	Group Means			
	PSP	CNS	NCT	F^{2}_{146}
1. Sociable	5.32	5.48	5.08	----
2. Verbal Ability	8.21	8.32	7.50	3.42 *
3. Emotionally Mature	6.10	5.70	5.81	1.25
4. Unrestrained	4.60	4.35	4.67	----
5. Aggressive	5.18	5.60	5.39	----
6. Enthusiastic	5.30	5.78	4.94	1.13
7. Conscientious	6.22	5.73	5.53	2.73
8. Adventurous	5.68	5.40	5.14	1.03
9. Sensitive	3.00	3.03	2.00	5.09 **
10. Individualistic	6.01	5.63	5.92	----
11. Worrying	4.42	5.10	5.47	4.29*
12. Self-Sufficient	6.32	6.23	6.19	----
13. Self-Controlled	4.55	3.88	4.42	2.65
14. Tense	3.89	3.98	4.47	1.49

	Scaled Vectors	
	I	II
1.	.22	4.93
2.	8.71	2.27
3.	-1.01	-7.96
4.	2.71	- .03
5.	1.93	2.24
6.	1.55	2.32
7.	4.88	-5.21
8.	3.45	1.46
9.	12.83	.06
10.	- .89	-8.23
11.	-6.06	5.95
12.	- .88	3.15
13.	-4.44	-10.72
14.	-6.42	-3.73

Latent Roots		% of Discriminating Variance
1)	.27	73%
2)	.10	27%

Wilks' lambda = .717

$F = 1.72$ $ndf_1 = 28$

$p < .025$ $ndf_2 = 266$

---

* Significant at the .05 level.
** Significant at the .01 level.

found in the grades 6 to 9 analyses of the HSPQ (Tables 5.7 and 5.8). The three variables considered here are the ones for which trends were consistent over the four HSPQ analyses. As it turned out, they were also consistent with findings from other instruments and were clearly interpretable. The HSPQ group differences which were inconsistent from analysis to analysis tended to be unique with respect to other results and were rather uninterpretable.

The second HSPQ variable, verbal ability, exhibits the same trends as did the other ability information. At Grade 6, the college non-science group is the more able, but the trend is not statistically significant. At grades 8 and 9 the differences become significant, this time the two college-bound groups equally excelling the non-college group. By grade 12 the PSP has "pulled away" from all groups, with the CNS boys about half-way between the PSP and the two non-college groups.

The sixth HSPQ variable is called surgency (+) vs. desurgency (-) by Cattell et al (1968) in their manual on this instrument. It is their most important component of extraversion-introversion. The overall trend in the analyses here is a non-science-technology (+) vs. science-technology (-) difference. The manual and corresponding test items describe surgency with terms such as "enthusiastic, happy-go-lucky, talkative, cheerful, serene, frank, expressive, mercurial, and quick." On the other hand, desurgent persons are "sober, serious, silent, introspective, depressed, concerned, brooding, incommunicative, sticks to inner values, languid and slow." They also report (p. 30) that desurgent children tend to day-dream, and are the oldest child more frequently than expected. Thus introversion, a prominent attribute of scientists, becomes evident at a very early age.

TABLE 5.15

"PERSONALITY" DISCRIMINATIONS

Predictor Classifications

	PSP	CNS	NCT	
PSP	57	4	12	73
CNS	22	11	7	40
NCT	13	2	21	36
	92	17	40	149

Probabilities for Group Centroids

	PSP	CNS	NCT
PSP	.56	.28	.16
CNS	.47	.39	.14
NCT	.36	.15	.49

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	5.41	-4.22	2.25	2.42
CNS	5.42	-3.07	1.51	2.86
NCT	3.77	-3.81	1.55	1.78

TABLE 5.16

"PERSONALITY" DISCRIMINANT ANALYSIS

(Grade 12 Plans)

	Group Means				
	PSP	CNS	NCT	NCNT	F^{3}_{145}
1. Sociable	5.29	5.50	5.03	5.30	---
2. Verbal Ability	8.54	8.16	7.58	7.60	3.15 *
3. Emotionally Mature	6.71	5.59	5.80	5.80	3.78 *
4. Unrestrained	4.37	4.98	4.85	4.00	1.78
5. Aggressive	5.10	5.43	5.35	5.80	---
6. Enthusiastic	4.95	5.71	4.88	5.90	2.62
7. Conscientious	6.34	6.09	5.43	5.20	3.27 *
8. Adventurous	5.63	5.53	5.18	5.70	---
9. Sensitive	2.49	3.05	2.60	2.90	1.06
10. Individualistic	5.71	5.91	5.98	6.10	---
11. Worrying	4.12	4.98	5.38	5.10	3.33 *
12. Self-Sufficient	6.00	6.10	6.68	6.60	1.74
13. Self-Controlled	4.78	4.26	4.03	4.20	1.83
14. Tense	3.83	4.40	3.95	3.40	1.59

	Scaled Vector
1.	-2.36
2.	9.20
3.	8.62
4.	- .50
5.	.50
6.	-2.54
7.	5.83
8.	-2.17
9.	.88
10.	- .46
11.	-6.32
12.	-9.01
13.	4.16
14.	4.90

	Latent Roots	% of Discriminating Variance
1)	.369	63%
2)	.156	26%
3)	.063	11%

Wilks' lambda = .594

F = 1.79 ndf $_1$ = 42

$p < .025$ ndf $_2$ = 392

---

* Significant at the .05 level.

Variable 7 produces college vs. non-college differences for all four analyses, but with only the grade 12 criteria yielding statistical significance. The college bound are at the high end of the scale, which is characterized as "conscientious, persistent, energetic, responsible, emotionally mature, and attentive to people and rules. . . This factor corresponds to the super-ego in psychoanalysis." High scores aare indicative of "success in a variety of performances requiring persistence, freedom from oscillation, and good organization of thinking." (p. 31 of HSPQ manual). Those students with low scores on this factor in junior high school were found to be dropping out of the two college-bound groups during high school.

INTEREST

The Kuder Preference Record, Vocational, was administered to this group at grade 11 so that trends observed here could be compared to those found for the grades-11-to-15 group. The ten scales are, of course, significantly related to grade 12 career plans (at the .001 level), but two of the scale trends, when compared to the 11:14 analysis in Chapter 3, are the really interesting results. In this 8:12 analysis the persuasive scale is barely significant (p .10). In the 11:14 analysis it was highly significant. The persuasive scale mean for the PSP, when classified by grade 14 plans, is lower than the corresponding mean when classified by grade 11 plans. From this and other Chapter 3 analyses it can be concluded tentatively that boys with an interest in dealing with people (high persuasive score) leave the PSP during college regardless of their score on the Kuder scientific scale.

TABLE 5.17

HSPQ "PERSONALITY" DISCRIMINATIONS

Predictor Classifications

	PSP	CNS	NCT	NCNT	
PSP	25	11	5	0	41
CNS	8	41	9	0	58
NCT	7	12	21	0	40
NCNT	1	3	6	0	10
	41	67	41	0	149

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT
PSP	.49	.33	.15	.03
CNS	.20	.50	.23	.07
NCT	.11	.32	.45	.12
NCNT	.08	.34	.45	.14

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	5.25	7.18	1.38	3.06
CNS	4.11	8.45	1.90	2.87
NCT	3.33	7.04	1.48	2.35
NCNT	3.13	7.35	1.56	1.67

Another interesting aspect of this analysis was the nature of the two discriminant functions. This time the college vs. non-college discrimination was slightly greater than science-technology vs. non-science-technology separation (see Centroids, Table 5.19). The key variable in the CNS discrimination was the outdoor scale, both non-college groups being high. The scientific scale was also a useful CNC predictor here but only because other patterns involved could make up for the low scientific mean for the CNS group.

MANIFEST INTEREST

The Reed Activities Inventory attempted to assess manifest science interest at grade 8 by asking students the extent to which they actually participated in science type activities during that school year (See items in Appendix). Using four derived factors as predictors of career plan groups at grade 12, there appears to be little relationship between grade 8 reported science activities and grade 12 plans.

TABLE 5.18

INTEREST DISCRIMINANT ANALYSIS

	Group Means				
	PSP	CNS	NCT	NCNT	F^{3}_{120}
1. Outdoor	40.40	38.22	47.25	46.00	3.31 *
2. Mechanical	42.83	38.24	47.22	41.78	5.19 **
3. Computation	29.60	29.27	29.31	29.33	---
4. Scientific	53.03	43.41	43.47	44.56	6.90 **
5. Persuasive	36.13	41.84	37.92	37.44	2.26
6. Artistic	24.80	21.55	27.64	25.89	2.74 *
7. Literary	20.13	23.49	17.58	18.33	4.73 **
8. Music	13.47	13.63	8.47	10.67	4.56 **
9. Social Service	35.53	38.35	33.36	39.22	1.47
10. Clerical	42.50	44.41	46.72	43.11	---

	Scaled Vectors	
	I	II
1.	65.80	6.92
2.	21.90	-29.57
3.	15.67	-18.68
4.	-79.95	-54.50
5.	20.30	25.93
6.	- 9.84	-59.40
7.	-10.61	40.55
8.	-28.76	-12.33
9.	-12.55	14.30
10.	5.17	- 4.66

	Latent Roots	% of Discriminating Variance
1)	.35	56%
2)	.25	40%
3)	.02	4%

Wilks' lambda = .582

$F = 2.21$ $ndf_1 = 30$

$p < .001$ $ndf_2 = 326$

---

* Significant at the .05 level.
** Significant at the .01 level.

TABLE 5.19

INTEREST DISCRIMINATIONS

		Predictor Classifications				
		PSP	CNS	NCT	NCNT	
Grade 12 Group Membership	PSP	18	8	4	0	30
	CNS	9	29	11	0	49
	NCT	4	5	27	0	36
	NCNT	1	4	4	0	9
		32	46	46	0	124

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT
PSP	.54	.28	.13	.05
CNS	.15	.58	.18	.09
NCT	.08	.26	.58	.08
NCNT	.14	.35	.42	.09

Discriminant Space

	Centroids		Variances	
	I	II	I	II
PSP	-13.35	-36.62	54.78	86.25
CNS	- 7.55	-25.67	99.90	101.56
NCT	.07	-34.62	55.90	79.85
NCNT	- 3.87	-32.16	65.39	154.11

TABLE 5.20

SCIENCE ACTIVITIES DISCRIMINANT ANALYSIS

	Group Means				
	PSP	CNS	NCT	NCNT	F^{3}_{159}
1. General	44.57	43.38	45.50	38.60	---
2. Woodsy-Birdsy	19.07	22.12	28.26	27.30	2.93 *
3. Tinkerer	22.00	19.91	22.81	20.20	---
4. Thinker	23.15	25.88	26.29	23.00	---

Latent Roots		% of Discriminating Variance
1)	.09	68%
2)	.04	29%
3)	.004	3%

Wilks' lambda = .879

F = 1.71 $ndf_1 = 12$

$p < .10$ $ndf_2 = 413$

---

* Significant at the .05 level.

One interesting finding here is that the one factor (2) producing significant group differences is more of a college vs. non-college discriminator than science vs. non-science. On this "woodsy-birdsy" factor, the two non-college groups are higher than the two college groups. Items on this factor include: visit pet stores, collect rocks, draw animals and plants, study fish and sea life, observe wild animals and birds, collect biological things, gardening, nature exploring hikes, etc. Looking back at the Kuder interest results (Table 5.20) the same pattern of means is found for the outdoor scale as is seen here on the woodsy-birdsy factor.

The generalization here seems to be that during junior high school, the "boy-scientist" is not necessarily going to be our future scientist. Abilities and other personality factors are more indicative of future decisions than the extent to which a boy participates in science type activities during junior high school.

TABLE 5.21

TEMPERAMENT DISCRIMINANT ANALYSIS

	Group Means				
	PSP	CNS	NCT	NCNT	F^{3}_{121}
1. General Activity	15.94	17.45	17.25	16.33	---
2. Restraint, Serious	16.52	14.27	11.53	10.11	6.81 **
3. Ascendance	15.94	17.16	14.81	14.22	1.80
4. Social Interest	18.90	18.04	17.19	16.67	---
5. Emotional Stability	15.58	15.45	15.89	15.22	---
6. Objetivity	16.52	14.82	13.81	11.11	2.60
7. Friendliness	13.52	11.47	10.19	9.33	2.84 *
8. Thoughtful	18.94	17.61	14.14	15.44	5.58 **
9. Personal Relations	16.00	15.10	14.47	13.22	---
10. Masculinity	21.29	19.82	21.17	19.00	1.51

	Scaled Vectors	
	I	II
1.	-16.55	- 8.02
2.	23.38	15.82
3.	2.96	-31.85
4.	14.84	23.54
5.	-28.40	- 4.15
6.	31.15	- 2.73
7.	2.31	- 6.92
8.	18.21	-10.78
9.	- 2.10	- 5.02
10.	.15	28.88

Latent Roots		% of Discriminating Variance
1)	.45	79%
2)	.09	15%
3)	.03	6%

Wilks' lambda = .616

$F = 1.97$ $ndf_1 = 30$

$p < .005$ $ndf_2 = 329$

---

* Significant at the .05 level.
** Significant at the .01 level.

TEMPERAMENT

The Guilford-Zimmerman Temperament Survey was administered to this group at grade 11. The results, summarized in Tables 5.21 and 5.22, show a significant difference (.005) among the four grade 12 criterion groups. Looking at the individual variables, the same trends are seen here as were found in the 11:14 temperament analysis of Chapter 3. Actually, these 8:11 temperament trends, using grade 12 plans are closer to the 11:11 analysis in Chapter 3 than to the 11:14 results, as would be expected since many migrations are yet to be made after grade 12.

The primary discriminant function in Table 5.21 is a college vs. non-college discriminator, with high restraint and thoughtful scores being related to college going. A weak second function clusters the PSP and NCT groups at the high end. Because the variables utilized in this second function are only slightly (and "non-significantly") related to group membership, it is probably not reproducible. That is, a subsequent sample from this population might produce quite a different pattern of loadings.

ENVIRONMENT

As in the case of abilities, the environmental domain became much more significantly related (p less than .0005) to senior high school plans that it was to junior high plans. Late in senior high school family socio-economic status (SES, variables 1, 2, 3 and 17) stands out as an important predictor of plans for the first time.

TABLE 5.22
TEMPERAMENT DISCRIMINATIONS

		Predictor Classifications				
		PSP	CNS	NCT	NCNT	
Grade 12 Group Membership	PSP	17	10	4	0	31
	CNS	7	23	19	0	49
	NCT	3	7	26	0	36
	NCNT	0	3	6	0	9
		27	43	55	0	125

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT
PSP	.53	.37	.08	.02
CNS	.24	.53	.18	.05
NCT	.09	.35	.47	.09
NCNT	.05	.35	.49	.11

Discriminant Space

	Centroids		Variance	
	I	II	I	II
PSP	13.48	4.86	12.11	9.67
CNS	10.62	2.75	18.34	11.57
NCT	7.26	4.76	11.50	13.94
NCNT	6.19	3.41	17.20	12.35

TABLE 5.23

ENVIRONMENT DISCRIMINANT ANALYSIS

	Group Means				
	PSP	CNS	NCT	NCNT	F^{3}_{157}
1. F education	5.65	5.84	3.81	4.00	8.29 **
2. M education	4.67	5.36	3.74	3.56	7.48 **
3. F occup. level	3.13	2.98	3.67	4.11	5.60 **
4. F nights out	1.04	1.14	1.07	.67	---
5. M nights out	.98	.95	.93	.56	---
6. Orderliness	2.17	2.20	2.02	2.44	---
7. Chores	2.20	2.13	1.98	2.44	---
8. Chores attitudes	2.74	2.80	3.10	2.89	2.14
9. Gets along well	1.76	1.67	1.95	1.56	2.85 *
10. Likes school work	1.85	1.86	2.14	2.33	4.00 **
11. FM aspiration	4.30	4.36	3.76	3.78	9.14 **
12. FM expectation	4.13	4.27	3.14	3.56	27.38 **
13. Oldest	.41	.25	.36	.33	1.14
14. Broken home	.11	.09	.17	.33	1.58
15. M works	.35	.28	.43	.22	1.00
16. F sci. hobby	.50	.42	.45	.33	---
17. Home scale	15.13	15.14	12.71	13.22	6.10 **
18. F helps sci. activity	3.09	2.53	2.83	3.33	---
19. Other male helps sci. activity	2.00	2.30	1.83	2.11	---

	Scaled Vector I
1.	3.76
2.	1.79
3.	1.47
4.	-1.82
5.	.68
6.	.45
7.	- .88
8.	-2.00
9.	- .83
10.	-1.25
11.	-1.80
12.	6.07
13.	-1.93
14.	-1.06
15.	-1.19
16.	.90
17.	- .19
18.	-3.10
19.	2.01

Latent Roots		% of Discriminating Variance
1)	1.03	80%
2)	.16	13%
3)	.09	7%

Wilks' lambda = .388

$F = 2.72$ $ndf_1 = 57$

$p < .0005$ $ndf_2 = 415$

---

* Significant at the .05 level.
** Significant at the .01 level.

Some of the variables which are not strictly descriptions of environment were included here because they are ratings by the parents. Variables 11 and 12, parents expectations and aspirations regarding amount of schooling son will receive, are much more significant here than in the 5 to 9 analysis. Two other ratings are significant for the first time, variables 9 and 10. Variables 9 tells us that the parents rate a non-science or non-technology boy higher, in regard to getting along with peers, than do parents of the science-technology boys. Regarding school work, (variable 10), the parents of the two college groups rate their sons higher on liking school work than do parents of the two non-college groups.

The discriminant analysis yielded three functions, only one of which appears useful. The major function was essentially based on SES. It placed the CNS group at the top, followed by the PSP, with NCNT and NCT at the low end. The second function separated out the NCNT group, but no confidence can be placed in this function because of the small size of the NCNT group. That is, the patterns utilized for this second function are probably unique to these particular data.

The separation of the four groups was rather good (61%) hits, considering the overlap between the two college bound groups. But again, with the large number of variables used here, the overall trends inspire more confidence than the hit rate.

TABLE 5.24
ENVIRONMENT DISCRIMINATIONS

Predictor Classifications

		PSP	CNS	NCT	NCNT	
Grade 12 Group Membership	PSP	13	26	7	0	46
	CNS	11	49	4	0	64
	NCT	5	3	33	1	42
	NCNT	1	2	2	4	9
		30	80	46	5	161

Probabilities for Group Centroids

	PSP	CNS	NCT	NCNT
PSP	.45	.46	.07	.02
CNS	.41	.56	.02	.01
NCT	.15	.05	.78	.02
NCNT	.20	.20	.27	.33

Discriminant Space

	Centroids	Variances
	I	I
PSP	1.78	.27
CNS	2.07	.27
NCT	.78	.30
NCNT	1.17	.27

CHAPTER 6

COMPARISONS ACROSS AGE GROUPS

In chapters 3, 4 and 5, particular age groups were examined and the observed relationships for all available predictors were analyzed and reported. In a sense this chapter turns the Scientific Careers Study "on its side" and examines certain variables across all of the age groups. This chapter, therefore, serves both as a summary of the major observed relationships and also is a new synthesis of the results of this investigation..

THE RISE AND FALL OF THE PSP

As all of the boys were contacted at least once each year, the size of the potential scientist pool (PSP) at each of the grades was determinable. Table 6.1 summarizes the portion of each sample who planned careers in science for grades 5 to 15. In the original 5th grade sample, 32% of the boys appeared to be heading toward careers in science. For the next two years this percentage actually increased and then during junior high school there was a slight decline. There appears to be a sort of recruitment limit during junior high school, where the PSP is as large as it ever gets. After junior high school and during senior high school a few boys move in but many more decide on careers other than science or engineering. The largest drop comes during the senior year of high school and this is not all due to decisions not to go to college. In fact the PSP loses about as many boys to the college non-science group as it does to the non-college technical worker group. Almost none of the boys originally in the PSP move into the non-college-non-technical worker group.

TABLE 6.1

PER CENT OF SAMPLE IN THE PSP
AT DIFFERENT GRADES

Grade	Sample	Size	
	141	150	192
5	32%		
6	39%		
7	48%		
8	44%	49%	
9	40%	49%	
10		43%	
11		41%	47%
12		27%	39%
13			32%
14			25%
15			19%

Of the two college samples consisting of males majoring in science, about one-fourth of both the sophomore and senior groups left science over the five years of the follow-up. The attrition from science seems to be just as great during college as it is right after college. The largest group contributing to the non-science group at this age are those who during college had intended careers in applied science. Very few of the research oriented PSP left science, either during college or after college.

One of the primary tasks of this investigation was to find relationships between measurable attributes of these boys and the criterion of staying in the potential scientist pool. Some boys left, some boys stayed. The question is, why? The search is for an explanation which is consistent with the observations.

ABILITIES

The relationships between abilities and educational decisions or career plans proved to be rather interesting. In the early years prior to junior high school, ability does not appear to be a consideration for boys with above average ability. Also at this early stage, the PSP does not stand out as the most able group, both groups planning college being equally able. In fact there is little difference in abilities between boys planning college and those not. Then from junior high school through senior high school, the ability information becomes more and more important. During the transition from high school to college, it becomes a very critical domain, with the PSP being the more able group. A surprising finding was that the college non-science students were no more able than their fellow college preparatory students who did not go on to college. Then a little later, the ability information available on the college boys showed very little relationship to post-college plans or decisions. So it is only in gaining acceptance to a college which trains scientists or engineers, or during senior high school, when deciding that science requires able students, that the less able drop out.

FAMILY SOCIO-ECONOMIC STATUS

SES measures produced relationships very similar to those found for ability. That is, the measures were unrelated to plans until the schools forced the college preparatory curriculum choice during senior high school, at which point it became slightly related to the criterion groups considered here. Its importance shot up dramatically in the high school to college transition. This was especially true for the non-science college bound. The major difference between the CNS group and the non-college boys is family SES. The SES measures available for the college boys indicate that the post-college decisions of science majors are not dependent upon family socio-economic status. This includes the choice of graduate work or not.

INTEREST

Science interest appears to be a fairly unstable dimension during late elementary and junior high school. Participation in science activities is not necessarily indicative of future career plans, or even present plans. Not until high school does interest become related to either present or future plans.

The surprising finding here with regard to measured interests was that the "wrong" scales seemed to be making the long-range predictions. Although the scientific interest scale on the Kuder is related to plans to be a scientist at the time the Kuder is taken, it is no more related to membership in the PSP five years later than were those earlier stated plans. That is, asking an 11th grade boy whether or not he wants to become a scientist is just as indicative of what he will be doing as a college junior with respect to science, as is the Kuder scientific scale. However, if that 11th grade student's scores score is also high on a scale which might be considered people-oriented or extravertive, such as the persuasive scale, then this tells you that the 11th grade boy may very well change from a science career. Thus it is the pattern of Kuder interest scores that has the long range validity.

Pattern was the key to group separation in the college interest analysis also. Professional interest was indicative of graduate work, but people contact was useful in distinguishing the graduate student scientist from those going to medical school. On the other hand, the MD and non-science groups, both high on people-contact interest, differed on production management interests, the MD being low group on this scale while the boys moving out of science were highest.

INTROVERSION

Outside of the emphasis upon the superior abilities of scientists, introversion is perhaps the most frequently cited "personality characteristic" of scientists. The difficulty is the confusion which surrounds this concept. Not only do laymen have different meanings in mind when the term "introvert" is used, psychologists are also inconsistent. For example, Freud's introvert is on the way to neuroticism "if he does not find other outlets for his pent-up libido." (1920). On the other hand, Jung (1921) considered introversion as a concept quite different from an independent of neurosis.

Eysenck (1953) in presenting an extensive summary of research, had done much to clarify introversion-extraversion, and has showed the orthogonality of this dimension to one called neuroticism. Eysenck considers these two basic dimensions as types, which is his term for second-order factors. Eysenck's conception of introversion seems to be a most reasonable, operational, and empirically based position, so it is the one adopted in the discussion which follows.

The primary traits which would have negative loadings on an extraversion (+) versus introversion (-) second-order factor are, for example: socially shy, persistent, rigid, irritable, inhibited, submissive, and reflective. Examples of positively loaded traits would be sociable, active, carefree, and ascendant.

In the Scientific Careers Study, several scales are relevant to the introversion-extraversion concept. Thus it seemed desirable to consider the specific ways in which future scientists appear introverted and just when these traits emerge as determinants of membership in the PSP. Before such a summary can be made, the scales which may be relevant must be defined.

The largest number of scales available are related to social extraversion. Each one has a little different shade of meaning, as can be seen in the following summary:

Instrument	Scale	Content of Scale Items:
Kuder SVIB	Persuasive Business Contact	Interview, sell, advertise, survey public opinion, arbitrate, solicit money, supervise department store.
GZ	Sociability	Many friends and acquaintances, entering conversations, seeking social contacts.
GZ	Personal Relations	Tolerance of people (not suspicious of others), faith in social institutions, not faultfinding or self-pitying.
Kuder SVIB	Social Service Welfare Worker	Social worker, slum recreation or clearance work, work with handicapped, help young people.
AVL	Social Values	Rights of others are important, unselfishness and sympathy are virtues, Lincoln is the hero, altruistic and charitable tendencies.

Four other scales can be considered as part of introversion-extraversion. Cattell et al (1958) also consider extraversion as a second-order composite of several primary traits, the most important of which is their surgency (/) versus desurgency (-) factor on the HSPQ. Persons with high scores on surgency describe themselves as enthusiastic, happy-go-lucky, talkative, cheerful, serene, frank, and expressive. Desurgent persons are sober, serious, silent, introspective, concerned, brooding and stick to inner values.

The GZ Temperament Survey contains two scales on which high scores are indicative of introversion. The GZ thoughtful (T) scale is "thinking introversion:" evaluate past actions carefully, frequently lost in thought, like to discuss serious questions of life, often meditate. The GZ restraint (R) scale is the rhathymia trait, where carefree is now at the low end of the scale. High scores indicate: take life seriously, analyze thoughts and feelings, persistence, do not crave excitement.

One final scale, GZ general activity, is related to extraversion. High scores on this scale indicate rapid pace, energy, vitality, keeping in motion, hurrying, etc. Items which contribute to low scores involve slow and deliberate pace, fatigability, pausing for rest, liking for slow pace, etc.

These, then, are the eleven scales which measured aspects of extraversion-introversion in this investigation. The remaining task is to summarize their relationship to the process of becoming a scientist.

The first indication of the relevance of introversion to the career development of scientists is found in the junior high school, where both the PSP and NCT groups scored low on the HSPQ surgency factor. Thus the tendency for scientists and technicians to appear more introspective, sober, serious, silent, etc. is seen early in their development.

In the study of the high school to college transition, only two of the scales on the GZ Survey were significant predictors of post-high school decisions, and both scales were indicative of the introverted PSP. The PSP was the high group on the thoughtful scale and the restraint scale. Thus as the PSP enters college as science majors, they appear less carefree and more reflective (or at least they report themselves that way) than do their peers who have made other types of decisions.

Other scales available for this group help to clarify more exactly the nature of the PSP introversion. The very low PSP scores on the Kuder persuasive scale indicate their rather complete lack of interest in dealing with people as objects of day-to-day activity, such as selling, interviewing, and supervising. Their disinterest in social s service work is not as dramatic. The differences not only lack significance, but the trend is more a college or not difference rather than a science or not difference, the two college groups being higher on social service than the non-college groups.

Similar trends were found when this group was administered the SVIB and AVL instruments two years after high school graduation. Although the PSP was very low on business contact, they were not the low group on welfare worker, nor were the group differences as significant on that scale. The differences on the AVL social scale were not significant, thus the PSP seems to express similar concerns for the rights and for altruistic values.

The other three extraversion traits available for this age group, the GZ sociability, personal relations, and general activity scales, showed no relationship to group membership at all. At this stage the PSP shows no difference in being active, or in seeing themselves as wanting friends, entering conversations, seeking social contacts, or in tolerance of people, faith in social institutions, faultfinding, etc.

Care must be taken in interpreting the results of the college groups, since these boys were selected as science majors, and are therefore pre-selected on certain variables. For example, no differences were found among the post-college criterion groups on the GZ restraint and thoughtful scales, because all four post-college groups were uniformly high on these two scales, indicating introversion.

However, other scales now become important. Boys going on to graduate school with an interest in doing some research show lower scores on personal relations (GZ), indicating their suspiciousness of others, lack of faith in social institutions, their faultfinding and self-pitying behaviors. They seem to want to find out for themselves.

Relatively high scores on two extravert scales, general activity and sociability (GZ), are very significantly related to moving out of science during and after college. The low group on general activity was applied science, with applied science and graduate science being equally low on sociability. A similar trend was seen for the SVIB business contact scale, the higher scores moving out of the three science groups.

Finally, the irrelevance of social values (AVL) and social welfare (SVIB) scales to this choice process is again seen. Neither scale was significantly related to group membership. Although scientists are far less interested in dealing with people in their day to day work, their concern for humanity and human rights appears to be no different than that of the other groups studied.

THE RORSCHACH TEST

The results of this investigation clearly show that the Rorschach Test, when handled in the traditional, rigurous psychometric fashion, has little or no relevance for the choice process studied here. This instrument was used in this study of career development because investigations had indicated its promise for this area of research; and because other studies which had indicated no predictive validity for the instrument seemed to exhibit serious shortcomings. These are summarized in Appendix E, which is a special section on the Rorschach Test.[1]

Because of the special care with which this test was handled, it can be said quite conclusively that no one should attempt to use this very expensive test in a study such as this and expect to learn anything new from the experience. The only case where the Rorschach revealed any significant group difference is when the college groups were defined by plans given at the time the Rorschach was administered. This result is also summarized in Appendix E.

PARENTS ASPIRATIONS AND EXPECTATIONS

Two questions on the parent questionnaire proved to be extremely useful predicators.

Question 25.	How far would you like your son to go in his formal education?
Question 26.	How far do you think your boy actually will go in his education?

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[1] See Roe & Mierzwa (1960) for a summary of related research.

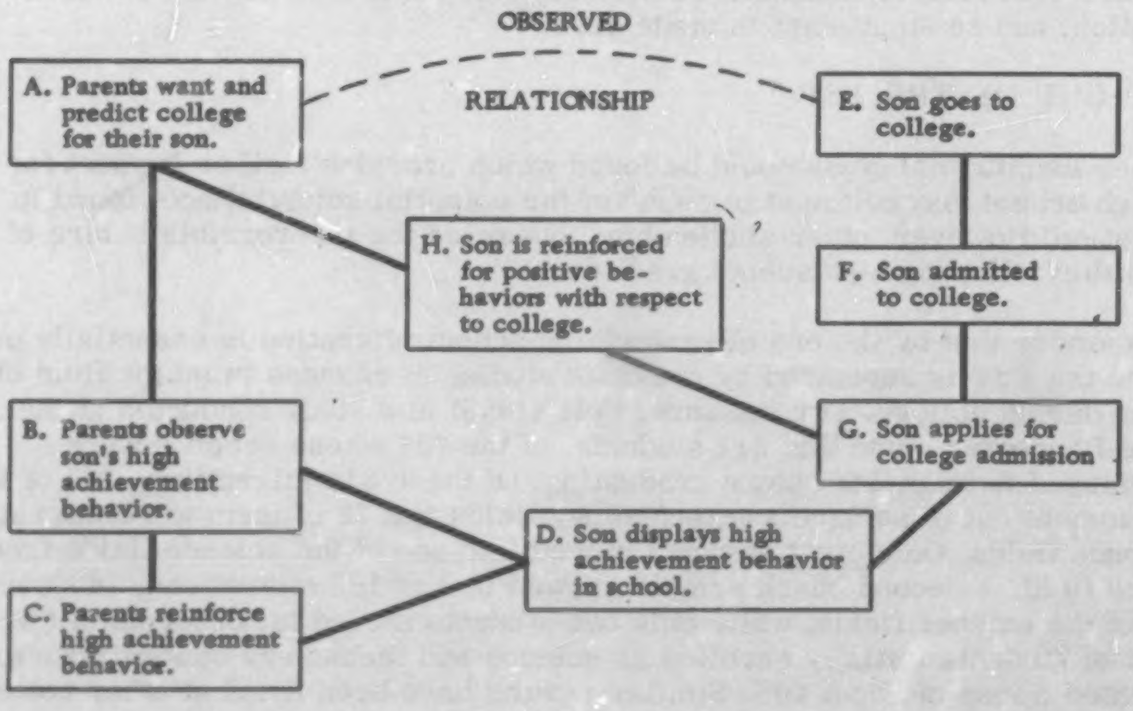
Both questions were followed by a five point multiple choice scale, from not finishing high school (low) to graduate school (high). Although useful predictors, these items proved to be difficult to interpret.

The overall results reported in this study suggest that there is information in these parental responses regarding the future decisions of their sons that is not found in the behavioral measures. Since the relationships involved here are no doubt complex, a schematic might be useful to help visualize the possible process.

In Figure 6.1, certain relationships are observed, others are hypothesized. The primary observed relationships are between (A) and (E), (A) and (D), (D) and (E). One of the reasons for the (A) and (E) relationship may be simply that parents observe that their son does well in school (B) and therefore predict he will go to college. What may also be involved here, however, is the circular relationship occurring over the period of school attendance, depicted by (B), (C) and (D). Parents who have high aspirations for son will be reinforcing high achievement behavior, thus contributing to the relationship between (A) and (D).

Also involved here is the indirect relationship between (A) and (G) through (H) resulting in (E). This relationship seems likely because not all of the observed relationship between (A) and (E) is "washed out" by a consideration of achievement behavior (D).

Figure 6.1
Parent and Son Behavioral Relationships


OBSERVED
RELATIONSHIP
A. Parents want and predict college for their son.
E. Son goes to college.
H. Son is reinforced for positive behaviors with respect to college.
F. Son admitted to college.
B. Parents observe son's high achievement behavior.
G. Son applies for college admission
D. Son displays high achievement behavior in school.
C. Parents reinforce high achievement behavior.

CHAPTER 7

REPLICATIONS, IMPLICATIONS, AND SPECULATIONS

> "It is safe to say that individual histories and
> biographies will never be written in advance no matter
> how 'evolved' psychology may become".
>
> William James (1890, p. 576)

This final chapter is concerned with the problem of relating the results of this investigation both to other research efforts and to the practical problems of guidance and science education in the schools. Following that, a few suggestions for further research conclude this report.

Comparisons of Findings to Related Research

This section represents an attempt to relate the results of this investigation to the results of others reported in the literature. This summary is more illustrative than exhaustive, as the purpose is merely to support with further evidence the primary conclusions drawn here, or to provide cautionary remarks where our findings are inconsistent with those of others.

One serious problem in psychology is that comparisons of studies are often difficult or even impossible because different psychologists use different research methods and instruments, and when they start with different data, they cannot easily use each others concepts, classification schemes, etc.[1]. But some progress can be made in this direction, and so an attempt is made here.

MOVEMENT OUT OF THE PSP

No other longitudinal study could be found which provides further support for the junior high school "recruitment plateau" of the potential scientist pool found in this investigation. However, other studies have observed the irreversible nature of PSP membership following high school graduation.

The assertion that by the end of senior high school migration is essentially out of but not into the PSP is supported by previous studies of changes in major field of concentration during college. For instance, Cole (1958) in a study conducted at the University of Rochester found that 311 students, of the 759 whose records were examined, changed their major before graduating. Of these 311 migrations, 167 of them involved movement out of science and technology fields and 72 of them were migrations between science fields. Only eight students moved into one of the science fields from a non-science field. A second check sample showed that of 168 migrations, 140 were leaving one of the science fields, while only two students moved in. In terms of the total number of students initially enrolled as science and technology concentrators, this represented a loss of about 40%. Similar results have been found at other colleges.

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[1] Physical scientists, for example, have a little easier task, because all measurements are reducible to three basic dimensions: length, time and mass.

Astin (1963) provides further evidence that students do not move into science during college. Studying National Merit Finalists, he found that only 2% of 1,631 students who entered college planning to pursue nonscience careers ended up pursuing careers in science at college graduation. Of 335 students aspiring to become artists, diplomats, journalists, lawyers or military officers, none had changed to science during the four years of college.

BEHAVIORAL MEASURES

Studies of abilitity have always shown scientists to be a superior breed. In fact, the analysis of Brandwin's data on highly talented high school students revealed that even among a high IQ group, the higher the scholastic ability, the more likely the student would stay in science (Cooley, 1959).

In spite of the fact that scientist group means are higher than other comparison groups, it does not mean that the dispersion about the means can be ignored. As Harmon (1961) has shown, students with IQ's as low as 100 have successfully achieved the Ph.D. in the sciences. What can be said is that the higher the general intelligence, the greater is the probability of staying in science. Also, if the measured intelligence is below the age group mean, the probability is very near zero.

Roe came to a similar conclusion in her study of eminent scientists (1951). She found that although intelligence was an important factor, it was by no means the decisive one. So whether the concern is with career choice or productivity, other factors need to be considered if vocational behavior is to be more completely understood and predicted.

The other major area of scientist behavior which has been studied is introversion-extroversion. Although studies report the scientist as "introverted", few tell what types of behavior this implies. In fact the observed behaviors which led to the introversion inference are often not disclosed.

However, there is sufficient evidence in the literature to validate the trends found in this Scientific Careers Study. Good examples are the studies of Roe (1952), Terman (1954), Brandwein (1955), and McClelland (1962). The contribution of the present study was to determine the specific aspects of introversion which are operating and when they become important in the process of career development, as described in Chapter 6 of this report. Although these other studies have shown that scientists tend to be introverted, this longitudinal study indicates that introverts become scientists. A previous alternative explanation was that scientists simply appear introverted by the nature of their work.

One problem which the behavioral measures present is how to reconcile the lack of relationships found for the projective tests used here with the many positive findings reported in the literature, findings which encouraged our use of these expensive techniques. In discussing the Rorschach, Eysenck's answer to this question is "very simply that positive findings are usually achieved in investigations which do not control adequately certain well known sources of error" (1959, p. 277).

Although it may not be desirable to accept Eysenck's rather extreme view, certainly those studies which have reported significant relationships between Rorschach behavior and scientific behavior need to be examined very closely in view of the lack of relationships found here.

ENVIRONMENTAL MEASURES

As far as environmental relationships are concerned, most of the research relevant to the questions considered in this investigation seem to be of two general types. Measures of early home environment have been related to personality development and more general environmental factors have been related to college attendance.

Within the vast literature relating child rearing practices and other home influences to subsequent behavior, the work of Roe (1957) stands out as most directly relevant to the career development of scientists. Her hypothesis that scientists come from homes which are characterized as avoiding the child, either neglecting or rejecting, has stimulated both her own research (Roe & Siegelman, in press) and that of others (see for example, Hagen, 1960).

The thesis investigation of Krinsky (1963, and see Appendix D of this report) has shown the complexity of the task of dealing with home environment variables. When that complexity is recognized and dealt with, the nature of the relationships are clarified, as in the case of the birth order variables which she examined.

The other area of research in which environmental variables have been used extensively is in the study of college attendance. Unfortunately, the variables have generally been directly related to college going, without any attempt to identify behavioral measures which may be intervening.

One recent paper which looks promising is that of Herriott (1963), where he develops a theoretical position for viewing correlates of educational aspiration. Actually, the methodological suggestions are his more important contributions, for others may wish to substitute a type of reinforcement principle for "perceiving the expectations of significant others."

Even though Herriott and others may establish how college aspiration is learned, aspiration must itself be considered within a set of predictors of college going, for aspiration is neither a necessary nor sufficient condition for actual college attendance. However, clarifying the relationships regarding aspiration does seem to be an important development.

Implications for Educational Practice

Our highly technical society presents certain serious problems to the student which not even his immediate ancestors had to face. Our youth today have very little opportunity to observe men at work, especially men doing technical and scientific work. Thus the schools have been asked to assume additional responsibilities, to provide information for students about possible careers, and to provide information for students about themselves in relation to possible careers.

In regard to the task of telling students more about themselves in relation to science and scientists, the use of test information must and can be improved. Students now spend an enormous amount of time taking tests, with too little payoff. In order to significantly improve the use of test information, schools will probably need to adopt modern data processing techniques. This will certainly be necessary if such summaries of test profiles as group membership probabilities are to be used.

This investigation has shown how a single test score, considered in isolation, can be misleading. The probabilities of group membership provide a means for considering multiple test scores in combination.

The probability score seems to be something which is easily translated to the student. Certainly a probability can be translated more easily than presenting the student with a variety of scores — percentiles, stanines, standard scores, A B C's, etc. In addition to being readily understood, a probability scores reflects the interrelationships among the individual scores, and the person's resemblance to a group for an entire system of data, such as the ten scales of the Kuder interest test.

Of course there are certain dangers involved in using these probabilities extensively. For example, it might cut down on the "people-oriented" students who stay with science through college and then decide that science is not for them. The probability scheme would tell such students that their chances of staying in science are not good. This study has shown that our science administrators and science teachers, for example, tend to come from this group who stay with science through college, yet because of their people-orientation, leave the actual practice of science but are still very useful members of a scientific society.

Perhaps one reasonable way to use this information is to identify those students who could stay with science, and make sure that they do not make school decisions which would make a scientific career impossible. In other words, we must make sure that students see the negative implications of decisions they are making. If they are able to see the possibilities they are eliminating by these decisions, they will have greater freedom in making subsequent decisions in their career development. It is probably not unreasonable to want to see that students are helped to attain the schooling that will make it possible for them to become the type of person that we think they are capable of becoming. It seems that the individual as well as society would gain from a reduction in the floundering which characterizes the career development of so many people. Probably greater productivity would be one result of earlier and more confident clarification of vocational goals.

Although most of these practical considerations are controversial, one thing we know with a high degree of certainty is that students do come forward with such questions as, "Do I look like a physicist?" The probabilities can give them the proportion of students with their particular combination of attributes that have gone on into physics or engineering. By providing this information the student can possibly make more realistic decisions.

One problem will be that as society changes, the nature of manpower supply and demand also changes, so that the use of group membership probabilities must be based upon continuously revised norms if we are to have confidence in them. It seems incredible that instruments continue to be widely used which provide norms that are completely out of date. Of course up to now continuous revision would have been far too costly. Today it is feasible if across the country cooperative school-university programs are set up for providing data processing services to the schools and research (normative) data for the university.

One observation which we have made in the course of the past five years is that the guidance emphasis appears to come too late. The present guidance effort is primarily to help those students become enrolled in some college who come forward with the desire (or whose parents come forward with the desire) to attend some college. This college placement problem, together with various administrative duties which guidance personnel are generally asked to assume, leaves too little time for attention to guidance at the point where high school curriculum choices are made. Educational data processing could assist here by identifying specific cases in which the student makes a decision which essentially eliminates a "higher" attainment of which the student is capable, or makes decisions which appear unreasonable for other reasons.

In discussing with guidance counsellors the possibilities of identifying "needy" students their reaction has been rather negative. They seem to feel that they are very busy just satisfying the daily demands placed upon them and have no time to even look for work, much less act upon it. This suggests the need for rather extensive development work to demonstrate the potential effectiveness of modern psychometric and data processing techniques for identifying particular types of deviant students, thus allowing guidance counsellors to place some emphasis where it is needed in addition to where it is requested. All that may be needed is to simply make sure that these deviants, whose decisions are inconsistent with their attributes, realize the decisions they are making, that they are aware of the possibilities they are "closing out" with that decision.

Of course modern data processing techniques will be effective here only if sufficient data are provided. Scholastic abilities alone are surely not sufficient. One obvious needed addition is an instrument which assesses future educational and career plans. This together with family background data and an improved interest-values battery, would be a big help in this screening which identifies those students who would benefit from individual guidance.

One very important implication for science education suggested by this investigation is the great importance of junior high school science in the career development of scientists. From the actual classroom observations which the principal investigator made of the schools represented here, one difficulty is surely the quality of the junior high science program. The emphasis which the federal government is currently placing on the problem of graduate work is fine, but they seem to be attacking the science manpower problem at far too late a stage. If the problem is one of maintaining a larger pool of potential scientists and engineers, surely much more attention needs to be given to the junior high school science program where students begin to "leave" science in very large numbers.

Because of the specialized nature of science and technology, the science teacher must assist in the guidance effort in these areas. One thing which science teachers can do is place students in contact with science and scientists, and not simply tell them the results of science. This particular recommendation stems more from two other research projects which this investigator has participated in during the past five years, one reported by Cooley and Bassett (1960) and the other by Klopfer and Cooley (1961). If students are to find answers to the question, "Is science for me?", we have to provide them with experiences which will tell the student something about himself with respect to science. If their concept of science is that which goes on in junior and senior high school science classes, then it might be desirable to move from the task of accumulating assorted facts and principles, to the inclusion of experiences which will show students how scientists "find out", how they develop hypotheses, etc.

The very superior ability of the PSP as it enters college should be reassuring to those who are concerned about science getting sufficient numbers of bright young men. On the other hand, those who feel that science and technology is attracting too much of the talent pool should be rather alarmed at our findings. Other important aspects of our society may suffer from lack of talent if this present trend is widespread and continuous.

One thing which our ability finding supports is our original contention that it is important to examine the question of who will stay in science as far as temperament, interest, values, etc. are concerned. Studying these non-intellective factors, it is possible to identify a large pool of science-oriented boys over a broad ability range. Because of other factors, such as family socio-economic status, many of these boys drop out of the PSP. Also, perhaps those of lower ability get discouraged and drop out of the PSP. Also, perhaps those of lower ability get discouraged and drop out of the PSP because they somehow feel science is for geniuses. (Talent hunts like the Westinghouse Talen Search may contribute to such discouragement).

The result is we spend an enormous amount of time and energy in college educating many who will leave science, while others, who would have stayed and functioned at some contributory level, are ignored.

Implications for Research

Probably the greatest procedural lesson which the experience of this research project taught the principal investigator is that one cannot do justice to five years of data collecting in a few months of analyzing and writing. Fortunately, we had put an enormous effort into computer programing in the course of the five years, so that the analysis task was simplified, but the computer cannot speed up the reflection and writing processes needed to integrate and summarize the volumes of computer output.[1]

This report is therefore not viewed as a final report except in so far as it satisfies the immediate demands of a research contract. Hopefully the coming academic year will provide opportunity for further analysis, reflection, and writing. However, many new problems are suggested by these results which cannot be answered by available data. These suggested problems, together with methodological implications of this research effort, will be the final considerations in this report.

METHODOLOGICAL IMPLICATIONS

This is probably the first research effort to employ an overlapping longitudinal design, and the modest success achieved here suggests both the promise of the technique and the need for further refinements. Now that most vocational psychologists view career choice as a developmental process, longitudinal studies seem to be essential. Also, since research is generally a series of successive approximations, the overlapping design makes it possible to accomplish more in a given time span. This in part reflects a conviction that it is more fruitful to study a particular occupational area over a long developmental span, than consider in detail "all" occupations at a particular developmental stage.

A related implication is the utility of broad educational and career decision categories as dependent variables. Although it may be useful to distinguish among very specific types of occupations when considering adults, it is unreasonable to make greater distinctions at earlier stages of development than students themselves do make or need to make. The questions asked here concerned the factors related to the initial attraction to a broad occupational area, science, and then subsequent factors as students made distinctions within science.

This investigation has also illustrated the advantages of applying discriminant analysis to logical domains of predictors, rather than pooling all available data at once. It makes it much easier to interpret results and has the added advantage of being able to compare the relative discriminating power of different types of information. Also, the number of discriminant functions which a particular domain yields is revealing. If only a single function results, there is only a quantitative difference among the groups.[1] If more than one function is produced, there is a type of qualitative difference which is generally quite interesting.

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[1] See Appendix F for a summary of computer programs which where developed as one aspect of this investigation.

The power of the probability-of-group-membership prediction system was clearly seen in this study. This technique not only results in surprisingly accurate predictions, but provides directly an estimate of error. If the probability of student $\underline{i}$ becoming a member of group A is .70, then you know you will be wrong 30% of the time if you "assign" all students like $\underline{i}$ to group A. Of course this technique is only as accurate as the extent to which groups can be separated. If the groups are separated, the probabilities summarize all the relevant information with respect to both predictors and criteria, whenever statements about individual students are desired.

RESEARCH POSSIBILITIES

The probability prediction system, when used in conjunction with discriminant analysis, presents a possible problem which requires further investigation. The problem concerns whether factors (student attributes) can be compensating or if they involve threshold values. A discriminant function since it is a weighted sum of the several predictor scores, allows variables to compensate for each other.

For example, take a simplified hypothetical case of two groups, with five predictors. The differences between the group means and the resulting discriminant vector may be as follows:

Means				
PSP		NS	Variable	Discriminant[2] Vector
$\overline{A}_1$	>	$\overline{A}_2$	A	+5
$\overline{B}_1$	=	$\overline{B}_2$	B	0
$\overline{C}_1$	<	$\overline{C}_2$	C	-6
$\overline{D}_1$	<	$\overline{D}_2$	D	-4
$\overline{E}_1$	>	$\overline{E}_2$	E	+5

In this example, a high discriminant score would indicate membership in the PSP. A student with a combination of high scores on variables A and E, and low scores on C and D will be assigned to the PSP because of a resulting high discriminant score. (His scores on test B is irrelevant because it receives a zero weight since group means were equal on B.)

The closer a student approximates this pattern of highs and lows, the higher his discriminant score. However, it is also possible to have a high discriminant score even if a student scores low on variable A, if he scores unusually high on E and/or unusually low on C and D. The question is whether these other factors can "make up for" low A or whether prediction could be improved by seeking threshold values for A below which PSP would be very unlikely, regardless of C, D and E.

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[1] This refers to the case where there are more than two groups. With two groups, only one function is possible.

[2] The "weights" for each variable used in computing the discriminant score, that score being a weighted sum of the original variables.

When this problem was considered in this investigation, it appeared as though the covariances took care of this. That is, such compensatory patterns were very unlikely because of the correlations among the predictors. However, our exploratory efforts in this regard were quite inconclusive and further exploration with this problem is suggested.

Further research is also needed in test development if the overlapping design is to be more successful. Reliable instruments are needed which are capable of measuring similar personality dimensions over a wide age range. One instrument which had been counted on for this purpose was the Rorschach, which was about the only test which could be administered over the age range represented here. It would seem possible to develop reliable, parallel forms of groups tests which could serve this purpose.

Certainly a third area of needed research is to pursue further the question of the environmental anticedents of career choice. This task should not be viewed as an attempt to make one to one correspondences between a specific environmental condition and a particular choice, but rather seek the behavioral link between aspects of the environment and career choice. Perhaps the concepts of environmental space and behavioral space, suggested in Chapter 2 of this report, will be useful in this regard. Also, Roe (1957) has shown a useful scheme for organizing research in this area, relating dimensions of early home environment to the development of interests.

One specific line of research which is suggested by this study is to further explore the question of the predictive validity of interest tests, such as the Kuder. Our results show that the Kuder science scale is no more predictive of entering science than simply asking the student if he plans to become a scientist. However, other scales on the Kuder, such as persuasive clerical, and social service, do provide information predictive of science career choice which improves upon asking the student.

A study which might throw further light on this question would involve administering the Kuder at, say grade 10, and obtaining career plans at that same time through interviews. Then at grade 12 the Kuder would be re-administered and career plans re-determined. The research questions would concern the relative shifting of plans and Kuder scores over that two year period.

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APPENDIX A

This appendix provides information on instruments used in this investigation. Space (budget) limitations prevented us from including copies of all mimeographed questionnaires, interview schedules, etc. Illustrative samples are provided. Interested readers may secure copies of other mimeographed materials cited in this report from the principal investigator Further information on the published tests are available from the test publisher.

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HARVARD UNIVERSITY
Graduate School of Education

Cambridge 38, Mass.
October 15, 1958

Dear Parents:

Nine school systems around Boston are working with Harvard University on a five-year study of career development for the U.S. Office of Education. The results may be of national importance in improving guidance services to students as they make decisions about school courses and programs.

In your local schools, your son has been selected as one of a group of boys from the 5th, 8th, or 11th grade. Each group will be interviewed and given aptitude, job-interest, and other tests at school during the regular school hours. The testing results will be available to your school's guidance director, but otherwise the material on individuals will be kept confidential.

Probably we will ask later if you can spare half an hour or so to tell us about your son's interests, and about your ideas on what kinds of work he does well.

If you do not wish to have your son stay in the research group, please have him bring the attached card back to his school principal's office. Since seven hundred boys are involved, we will have to assume that you are willing to have him included if we do not hear from you by October 31.

Please drop me a note or call my office (UNiversity 8-7600, extension 2544) if you would like any more information.

Sincerely yours,

William W. Cooley, Director
Career Development Study

WC:ep

Enclosure

HARVARD UNIVERSITY
Graduate School of Education

Dear Mr.

This fall we are undertaking an extensive research project which will attempt to give us some insight into the process of vocational choice. It is hoped that the resulting information will be useful in guiding future college students in their career development. So that we might have a broad sample of students in our study, a number of colleges and universities in this area have agreed to let us ask some of their students to participate, and your school is one of them.

The purpose of this letter is to seek your assistance. We would like you to be one of the students included in our sample. It will involve 2 or 3 hours of testing and a short interview this first year, and then we will attempt to maintain some contact with you for the next five years through post cards and short questionnaires. We will also seek your permission to include your academic records in our analyses. All testing and interviewing will be done at your school.

So that we can arrange a time to meet with you, please fill out the enclosed card and mail it to us as soon as possible. Fill out the top three lines as indicated, adding the name of your school after your name. Place X's in the spaces indicating when you have classes or other weekly engagements, changing the times on the card if they do not correspond to your hours.

If you feel that you are unable to participate in this research project, we would appreciate your letting us know, either by letter or phone, telling us, if you care to, why you prefer not to take part.

Also, if you have any questions or uncertainties about participating, call and we will be happy to discuss them with you. Our phone number is UNiversity 8-7600, extension 2544. Thank you for your cooperation.

Sincerely,

William W. Cooley, Director
Career Development Study

HARVARD UNIVERSITY
Graduate School of Education

7 Kirkland Street
Cambridge 38, Mass.
February 6, 1959

As you know, your son is one of a group of boys participating in a study of how, when and why certain types of jobs are chosen and pursued. Nine school systems and five colleges are cooperating with Harvard University in this study sponsored by the U.S. Office of Education.

The purpose of this letter is to seek your cooperation. We realize that the parents often play an important part in helping boys decide on reasonable career plans. Also, the people most likely to understand boys and their vocational plans are the parents, who are able to observe this whole process of growing up and choosing a career. Therefore, we need some information from you. Please answer the attached questions and mail the completed form in the enclosed stamped envelope.

Your cooperation in this study is necessary if we are going to be able to continue including your son. We will greatly appreciate your returning the questionnaire as soon as possible.

It is our belief that, although your specific answers will be seen only by our research staff, the combined answers of the parents included in this study will greatly assist young boys like your son as they go through school.

Sincerely,

William W. Cooley, Director
Career Development Study

WC:ep

SUMMARY SHEET
11-15

I D________________

Name________________________ School________________

Career Goals:

5th (recalled)________________________

8th (recalled)________________________

11th (interview)________________________

12th (questionnaire)________________________

13th (questionnaire)________________________

14th (questionnaire)________________________

15th (questionnaire)________________________

College Plans:

Major (11)________________________

College (12)________________________

Non-College plans (12)________________________

Follow-up Information

1960-1961 (13):________________________

1961-1962 (14):________________________

1962-1963 (15):________________________

Parent Questionnaire (11):

Sons goal________________________

Father's hopes________________________

Mother's hopes________________________

Classifications:________________________

PARENT QUESTIONNAIRE

Pupil's name ______________________ **School and Grade** ______________

Home Information Blank
Career Development Study
Harvard University

Directions and Background Questions:

1. **If at all possible, the father and mother should answer the questions together. However, we would like to know who actually fills out the questionnaire. Name of parent or guardian filling out questionnaire:** ______________

2. **Describe the composition of the family now living in your home. Example: This boy lives with his natural father, step-mother, two older brothers, and his grandmother (his father's mother).**

   ____

   ____

   ____

3. **If the boy is now living with his natural mother and father, skip page 2 and go on to page 3. If he is not, please read page 2.**

4. **The questionnaire takes only about 30 minutes to complete.**

5. **All answers will be held strictly confidential.**

* * * * * * * * * * *

Please Return to:

Dr. William W. Cooley
Harvard University
7 Kirkland Street
Cambridge 38, Mass.

Skip this page if boy is living with his natural Mother and Father

If the boy in our study is not now living with his natural mother and father, please answer the following questions before going on to page 3.

Many of the questions on the following pages refer to the father and mother of the boy in our study. For some family situations, these terms need to be clarified. We are interested in learning a little bit about those who are serving or have served as this boy's mother and father. In other words, for some of you filling out this questionnaire, "father" may refer to step-father, or foster father, or a father no longer living in the home. The important thing is to answer father questions in terms on one person only. The same is true for mother. So that we might know which situation applies to you, please indicate which parents the questions will refer to by circling one description of "father" and one of "mother".

All questions about father will refer to this boy's:

1. foster father now living with boy.
2. step-father now living with boy.
3. male guardian now living with boy.
4. natural father or one of the above no longer living with boy. In this case, questions about the father's present activities will refer to that time when he was living with son.
5. other: ______________________________

If the natural father is no longer living, indicate how old the boy was when his father died.

Boy's age at death of father:

All questions about mother will refer to this boy's:

1. foster mother now living with boy.
2. step-mother now living with boy.
3. female guardian now living with boy.
4. natural mother or one of the above no longer living with boy. In this case, questions about the mother's present activities will refer to that time when she was living with son.
5. other: ______________________________

If the natural mother is no longer living, indicate how old the boy was when his mother died.

Boy's age at death of mother:

1. How much formal education did the father have? (Circle number of highest level reached.)
   1. some grade school
   2. finished grade school
   3. some high school or trade school
   4. finished high school or trade school
   5. some college, business or technical school
   6. finished technical or business school
   7. finished junior college
   8. finished college
   9. attended graduate school or professional school after college
   10. do not know

2. How much formal education did the mother have? (Circle number of highest level reached.)

1. some grade school
2. finished grade school
3. some high school
4. finished high school
5. some college, technical or business school
6. finished technical or business school
7. finished junior college
8. finished college
9. attended graduate school or professional school after college
10. do not know

3. What is (or was) the father's occupation? Be as specific as you can.

Examples: sells and repairs jewelry, is foreman over 14 men, operates a milling machine, vice-president in charge of sales.

____

4. For what kind of business or organization does he (or did he) work?

Examples: electric power company, has his own retail store, state government, etc. If his occupation is an officer of a company (president, branch manager, etc.) indicate the approximate number of men employed.

____

5. Does the mother have a paying job? (Circle one answer.)

1. she works full time.
2. she works part-time.
3. she does not have a paying job.

6. If the mother works full or part time, please describe what she does and tell whether this is done at home or away from home.

____

____

7. Where was the father born? (Circle one answer.)

1. in the United States
2. in Canada
3. in the British Isles
4. in Mexico or South America
5. in Europe
6. in Russia
7. in East Asia
8. in Africa
9. other: ______________________

8. Where was the mother born? (Circle one answer.)

1. in the United States
2. in Canada
3. in the British Isles
4. in Mexico or South America
5. In Europe
6. in Russia
7. in East Asia
8. in Africa
9. other: ______________________

9. About how many evenings a week does the father spend in various types of social activities (such as political clubs, card clubs, professional groups), either with or without his wife: (Circle the approximate number of nights per week.)

0 1 2 3 4 5 6 7

10. Some people spend much time reading, while others find other activities more profitable. About how many hours a week does the father spend reading? Also, indicate the type of reading he does. (newspaper, type of magazine, type of book)

Type of Reading	**Hours per Week (approx.)**

11. Does the father engage in any particular hobbies at home? (Describe them briefly.)

12. Does the father, or any other adult in the home, spend time with this boy in hobby work, or other spare time activities? Explain.

13. About how many evenings a week does the mother spend in various types of social activities (church groups, card clubs, PTA, etc.), either with or without her husband. (Circle the approximate number of nights per week.)

0 1 2 3 4 5 6 7

14. About how many hours a week does the mother spend reading? Also indicate the type of reading she does (newspaper, type of magazine, type of books, etc.)

Type of Reading	**Hours per Week (approx.)**

15. Does the mother engage in any particular hobbies at home? (Describe briefly.)

16. Please describe any health problems or physical disabilities which your boy has that may affect his education or eventual choice of jobs.

17. Some people are very careful about keeping their possessions in neat and orderly condition. Other people are too busy with other activities to keep things in order. Please tell us how your boy cares for his things.

1. **has a place for everything and tries to keep everything in its place.**
2. **keeps good care of things but not always in an orderly fashion.**

3. not much concerned about orderliness, but usually has things in workable condition.
4. almost no concern for orderliness.

18. To what extent is your son given responsibility for doing certain jobs (chores) around the house?
1. he has several tasks a day to perform
2. at least one task a day
3. two or three chores a week
4. seldom more than one a week
5. he has not been assigned responsibility for any particular home chores.

19. About how many hours a week are spent on these chores around house?

20. What is your son's attitude toward these chores?
1. he finds them particularly distasteful.
2. he doesn't like doing them.
3. he doesn't seem to mind too much.
4. he seems to enjoy doing most of them.

21. How well does this boy get along with other children his age?
1. he gets along with other children better than most boys his age.
2. he gets along as well as other boys.
3. he does not get along as well as many boys his age.

22. How does your boy feel about school work?
1. enjoys it a great deal
2. likes most things at school
3. seems indifferent about it
4. dislikes school work very much

23. Has your boy experienced a special difficulty with any phase of school? (Circle one or more.)
1. reading
2. arithmetic
3. spelling
4. getting along with other children
5. speaking in class
6. getting along with his teachers
7. no special difficulty
8. others (describe)

24. In what school courses or other school activities would you especially like your son to show improvement?

____

____

25. How far would you like your son to go in his formal education?
1. finish trade school
2. finish high school
3. one or two years to college or a special training school
4. graduate from college
5. graduate school or some professional school after college (to prepare to be a medical doctor, lawyer, university professor, etc.)

26. How far do you think your boy actually will go in his education?
   1. he will not finish high school or trade school
   2. he will stop after finishing high school or trade school
   3. he will go one or two years to college or a special training school
   4. he will graduate from college
   5. he will go to some professional school or graduate school after college (to prepare to be a medical doctor, lawyer, university professor, etc.)

27. Of the various things your son does, what seem to you to be the sort of thing he likes to do most of all? (List in order his favorite activities.)

1) ____________________

2) ____________________

3) ____________________

28. Of the things which your son does, what pleases you most? ____________________

____

Note:
The following questions refer to the boy's eventual job. Some of the boys in this study are only in the fifth or eighth grade, and so nothing definite about his future can be said at this time. However, please answer the questions in terms of present plans, even though these plans may be very temporary at this time.

29. Describe your son's present vocational ambitions. What do you think he wants to become, even if it seems to you unreasonable or just a passing fancy?

____

30. How long has your son had this idea for an eventual job?

31. What does this boy's mother want him to become when he finishes school?

____

32. Does the mother make her desires known to the son, or does the mother feel her son's choice of vocation is pretty much his own concern? Explain.

____

____

33. What does this boy's father want him to become when he finishes school?

____

34. Does the father make his desires known to the son, or does the father feel his son's choice of vocation is pretty much his own concern? Explain.

____

____

35. **Please describe other adults, besides this boy's mother and father, who may be (or will be) greatly influencing his vocational decisions. Indicate the relationship (if any) of those adults to your son, their occupation, and their education.**

1)____

2)____

3)____

36. **Use the remaining space to make any further comments you care to regarding yourselves or your son and his future.**

8 and 11
INTERVIEW

Career Development Study
Harvard University

I'm _____ from Harvard University. Same career study you took the tests for, but what we talk about today will not be reported to your parents or school. Spare-time interests, career plans. Information you give may help boys your age all over the country.

Name ____________________ Age _____ Interviewer __________

Town __________ School __________ Grade _____ Date __________

General Impressions:

First choice career goal rated: ____________________

A. Knowledge of job role:
1. Stated in clear and realistic terms what job involves.
2. Could give only a general statement of what job involves.
3. Had very little idea of what job involves.
4. Had almost no idea of what job involves.

Includes:
___ misinformation
___ fantasy distortion
Reason: __________
____

B. Knowledge of training required:
1. Had clear and realistic concept of training required.
2. Could give only general statement of training required.
3. Had only a slight idea of training required.
4. Had almost no idea of training required.

Includes:
___ misinformation
___ fantasy distortion
Reason: __________
____

C. Subject's confidence in career goal:
1. Expressed great confidence that he could achieve his first choice.
2. Expressed confidence in first choice but considered alternatives as possible.
3. Some confidence in first choice but alternates are equally possible.
4. Had very little confidence in first choice. Alternates are probable.
5. Expressed no real first choice.

D. Interpersonal relationships — male in peer group:
1. Many boys.
2. 2 or 3 boys.
3. Only 1 boy.
4. No evidence of any boys.

E. Interpersonal relationships — females in peer group:
1. Many girls.
2. 2 or 3 girls.
3. Only one girl.
4. No evidence of any girls.

F. Interpersonal relations with adults:
1. Gets along well with adults.
2. No significant positive or negative reaction to adults.
3. Mentions one or two difficulties getting along with adults.
4. Frequent difficulties getting along with adults.

G. Prediction:
8th Grade: This boy (will) (will not) take the college preparatory course in high school.
11th Grade: This boy (will) (will not) go on to college and (will) (will not) major in a natural science or engineering.

A. Spare-time Activities Outside of School: (number all free responses)

O = Often S = Seldom

	No	A	E	W	S		Alone	Family	Others
1. Baby-sit									
2. Camp									
3. Church									
4. Clubs									
5. Dating									
6. Family Camp									
7. Group of Friends									
8. Hobby **									
9. Home Chores									
10. Homework									
11. Job									
12. Movies									
13. Play Music									
14. T.V., Radio Phono									
15. Reading**									
16. Sports									
17. Trips									
Others									

**Prime if not volunteered

18. Of all the things you do outside of school, what do you like best? Why?

____

____

B. In-school Activities

1. Clubs ____________________

____

2. Sports ____________________

____

3. Favorite subjects, reasons ____________________

____

____

4. What kind of grades do you get? Do these grades give a real picture of your abilities?

____

____

5. What do your parents think about your grades? ____________________

____

____

____

6. How about teachers? Do you have a favorite? (Man) (Woman) What does he (she) teach? What do you like about him (her)?

____

____

7. What things do you like least about school? Why? ____________________

____

____

____

C. Career Plans:

1. What sort of job would you like to do?
2. Why do you prefer that kind of work?
3. Who do you know who does that?
4. What sort of things would you do as a ____________________?
5. How much education will you need?

6. Where will you probably go to get this training?

7. If by some chance, this plan doesn't work out, what other types of jobs would you be interested in doing? Why?
   a.
   b.
   c.

8. Who do you know who has jobs like these?

9. Would you like to do work something like your father's? Why? What does he do?

10. Do your relatives or friends have any types of jobs that interest you?

11. Which relatives have you talked to about possible careers?

12. What does your father want you to go into? Mother?

13. Do you think a boy's family should help him decide on a career?

14. Who else have you talked with quite a bit about possible careers for you?

15. Of all the possible jobs, which one do you really expect to end up doing?

D. Self-ratings of Abilities:

1. You seem most interested in getting training to become a
   Do you expect any difficulties in the studying you will have to do?

2. What things about the job itself may be difficult for you to do well?

3. Do you have any health problems that may affect your work?

E. Interpersonal Relations

1. Now let's talk about your personal interests. In general, would you rather do things with other people or by yourself?

2. How many friends do you have? How do you feel about that?

3. How many of these friends are real close buddies?

4. We've been talking about your buddies. Now, what about girls?
   How often do you go out with a group of girls and boys?

5. How often do you double-date?

6. How often do you take out a girl by yourself?

7. Are you going steady?

8. How many steady girls have you had in the past?

9. **Do most of the boys in your class date more or less than you do?**

more **about the same** **less**

10. **Boys date for many reasons. What are some of the main reasons you take out girls?**

F. Recall of Earlier Career Choices

(11th Grade) This study runs from fifth grade through college. Would you think back to your interests when you were in the eighth grade. What career did you want when you were in the eighth grade?

Now think back to the fifth grade. What did you want to become back then?

(8th Grade) This study runs from fifth grade through college. Would you think back to your interests when you were in the fifth grade. What career did you want when you were in the fifth grade?

When did you become interested in becoming a ________________________?

Anything else you want to tell me about your career plans?
Do you have any questions about this study? (Remind about keeping in touch.)

LIST OF STANDARDIZED TESTS

Allport, G.W., Vernon, P.E., & Lindzey, G., *Study of values*. Cambridge, Mass.: Houghton Mifflin Company, 1960.

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APPENDIX B

THE CONSTRUCT VALIDITIES OF INSTRUMENTS USED IN THE SCIENTIFIC CAREERS STUDY*

by Kenneth Jones, IBM Fellow, Harvard Computing Center

Cronbach and Meehl (1955) have discussed four types of test validity. These are termed the content, concurrent, predictive, and construct validities of the test. Most psychometric tests are conceived in terms of their predictive validity. The content validity of a test is for the most part a subjective judgment, or agreement on the part of the test-makers and users, that the questions composing a test or scale are relevant to the particular behavior being investigated. A thorough understanding of the content of a test, and the meaning of the items for the subjects is of importance to both the test-maker and the user. A lack of awareness of this may cause great difficulty when the user attempts to rationalize predictive relationships resulting from a particular experiment. This difficulty usually results from a difference in interpretation placed on the name of the scale by the test-maker and the experimenter. Content validity is usually dealt with by having potential items screened by a group of experts. In practice this is probably the most feasible way of obtaining good items.

Of the remaining three types, "concurrent", "predictive", and "construct" validities, concurrent concerns the degree to which the particular test is correlated with an external concurrent criterion. This term indicates an interval between administrations over which behavior change in unlikely. This, of course, would be different for various behaviors. Predictive validity concerns the degree of correlation between the test and an external criterion measured at some future time. One must assume that in any description of this type of validity the time interval would be specified.

The concept of construct validity is much more diffuse than the above. It concerns the test's relations to many other measures in a situation where both the test under consideration and the "criteria" are considered suspect. Cronbach and Meehl describe this as considering the test in relation to the "nomological network."

Although the Scientific Careers Study dealth with five samples of students, one group, those initially in grade 11 of high school, were tested somewhat more extensively than the others. This group of 190 students was selected as the one within which the concurrent and predictive relationships among the instruments would be investigated. Out of these analyses, it was hoped to derive some understanding of the construct validity of each instrument. Also of great interest, was the redundancy, or "informational overlap", between pairs of the instruments. For example to what extent does the Strong Vocational Interest Blank contain variance also contained in the Allport-Vernon-Lindzey Study of Values. The unit of analysis here is the instrument rather than the scale. This presents certain technical difficulties, since the instruments each contain a number of scales which are logically different in content. Simple correlation analysis is ruled out since a total score on an instrument is meaningless. However, canonical correlation technique enables one to relate two sets of variables by means of linear combinations of each set. Thus one gets one or more coefficients which describe the common variance. The problem is then reduced to comparing sets of coefficients in order to make statements about degrees of information overlap.

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* This Appendix represents a portion of Dr. Jones' doctoral dissertation which was partially supported by the Scientific Careers Study. For further details, see Jones (1963).

The following instruments were investigated:

1.	Kuder Preference Record	(Grade 11)	10 scales
2.	Strong (SVIB)	(Grade 14)	11 scales
3.	Study of Values (AVL)	(Grade 14)	5 scales (1)
4.	Environmental Press(2)	(Grade 11)	11 factors
5.	California Test of Mental Maturity (CTMM)	(Grade 11)	4 scales
6.	Guilford Zimmerman Temperament Survey (3)	(Grade 11)	9 scales
7.	Rorschach Test		14 factors
	Total scales		64

The 64th order correlation matrix was generated, and in the course of the analyses the 385 multiple correlations of the scales of each instrument predicting each scale of the remaining instruments were evaluated (i.e. with the 14 scales of the Rorschach as predictors there would be 10 + 11 + 5 + 11 + 4 + 9 = 50 multiple R's. This was done to gain an understanding of the nature of the informational overlap described below. Next the complete set of canonical correlations for each instrument pair were computed. The matrix of the 21 best (i.e. first) canonical coefficients is given in Table B1.

These coefficients represent the relationship between the best linear combinations of predictors and criteria. However, the magnitude of this relationship is affected by the number of constants fitted to the regression equation; hence it is a function of the scales peculiar to each instrument. Therefore one may not compare one canonical with another without considering the number of degrees of freedom involved in each case. Furthermore, although the first canonical correlation gives the common variance between the best linear combinations of predictors and criteria, there may be other linear combinations with nearly as great overlap. It seems to me that for the purposes

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(1) Religious scale was dropped due to the ipsative nature of the instrument.

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(2) The 11 factors of the environmental "Press" domain were derived from a factor analysis (principal components followed by Oblimin rotation) of 30 items drawn from three socio-economic questionnaires administered to the students, and their parents. These factors may be described as follows.

factor I	Family cultural level
factor II	Father's and Mother's aspirations for their son's level of education
factor III	The size of the subject's immediate family
factor IV	Father and Mother do spare time reading
factor V	Protestant - Catholic
factor VI	Father has science hobby
factor VII	Father has a business occupation vs. a technical one
factor VIII	Father and Mother spend many nights out
factor IX	Father missing
factor X	Parents hope son will enter a business occupation vs. a technical one
factor XI	Subject has physical or emotional problem

---

(3) Masculinity scale dropped.

of investigating construct validity among a population of psychometric tests an adjusted measure of total informational overlap between tests is more appropriate. The amount of common information across sets is measured by their common variance; however the relevance of this measure is dependent on the amount of common variance expected by chance alone. Perhaps this may be considered as analogous to the signal-to-noise problem in communication theory.

Bartlett (1941), and Rao (1952) suggest tests for the "non-randomness" of the complete set of canonical correlations. These are dependent on the computation of a Wilks lambda for the total set. This is a function of the continued product of the roots of the matrix.

$$(R_{21}\, R_{11}^{-1}\, R_{12} - R_{22})$$

where R_{11} = the correlation matrix for the predictors

R_{22} = the correlations of the criteria

R_{12} = the interset correlations

$R_{21} = R'_{12}$

These roots are the squares of the canonical correlations. Lambda is equal to:

$$\Lambda = \prod_{i=1}^{q} (1 - R_i^2)$$

where q is the number of variables in the smaller set

This tends towards zero as the first root tends toward one. The method of Bartlett uses an approximation to transform Λ to a χ^2 value. The method of Rao uses another approximation to derive an F ratio. Rao's method entails a smaller error factor, and is used below. However, both tests were computed and with the relatively large number of cases used here the differences in computed probabilities were negligible.

Rao (1952) gives the following approximation to computing the probability of a a Wilks' :

$$F = \frac{1 - \Lambda^{1/s}}{\Lambda^{1/s}} \cdot \frac{ms + 2\lambda}{pq}$$

where: $s = \sqrt{\dfrac{p^2 q^2 - 4}{p^2 + q^2 - 5}}$

and $\lambda = -\left(\dfrac{pq - 2}{4}\right)$

In order to compute the probabilities of a wide range of F's the resultant values were approximated to a normal deviate by using the transformations given by Kelley (1948). Table B2 gives the values for these normal deviates. The larger the normal deviate becomes; the smaller is the probability that the total variance represented as common by the q linear relationships is due to random effects. In Table B3 are listed the probabilities associated with the above normal deviates.

If the Rorschach is ignored, the above matrices are roughly circular. That is, the relationships decrease as one moves down the list to a point, and then they begin to increase. For example the G-Z has more information in common with the Kuder than does the Press. Some of the relationships here are concurrent and some are predictive.

The above matrix may be useful in deriving an understanding of a test in terms of a network of other similar, and dissimilar tests. For example, if we look at the environmental Press instrument, we see that it is primarily related to interests and values. Its relationship with the ability and personality instruments is much more distant. These relationships contribute to our understanding of the nature of the Press instrument. Conversely, the relationships of Press to the other instruments contribute information about their characteristics. If we look at the Rorschach, we see that it is, surprisingly, more closely related to interests (and possibly values) than any of the other instruments. These relationships suggest that the Rorschach (as here scored) is invalid for measuring the kinds of behaviors measured by the other instruments. It does not suggest that the Rorschach is not measuring any behavior. However, those data do not tell us anything about the kind of information it contains beyond the fact that there is some communality with the Kuder. Clearly a better understanding of the kind of information overlap which does exist may be attained by a detailed examination of the multiple correlations, the beta weights, and the zero order correlations which underlie these relationships.

The canonical and multiple relationships were computed by means of an IBM 7090 FORTRAN program which is my modification of a Cooley and Lohnes (1962) canonical correlation program. This program is called Supercanon. It was developed with the idea of gettin out of a single analysis as much information about the nature of the batteries, as possible.

As an example of how the information from the program may assist in elucidating the relationship of one battery with another given in Table B4 are the canonical equation for the overlap of the Kuder with the Rorschach factor scores. Only one root was significant; therefore we may disregard the canonical equations of higher order than the first.

One can see from the beta weights in Table B4 that of the Rorschach factors termed Human Movement (HM), human parts (H part), Sex, and Mask are the primary predictors for a combination of Kuder Scales composed mainly of variance associated with Mechanical interests, and a lack of interest in Artistic and Clerical activities. Here one is tempted to postulate a "factor" common to both batteries perhaps - masculinity-femininity or extroversion-introversion. At this time however, this would be pure speculation. More information can be gained by looking at the multiple, and zero order correlations underlying the above equation. Using the 14 Rorschach factors as predictors only three multiples are significant with a probability less than .05. They are given in Table B5.

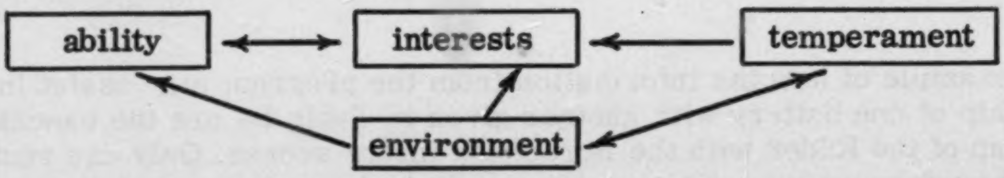
From these regressions it may be inferred that it is primarily the tendency not to give Animal, Nature, or Human parts responses which related to mechanical interest. The tendency to given Human movement, Emblem, Mask, and Art responses is associated with artistic interest; and lack of Art, Mask, and Furs response relate to clerical interest.

With the Kuder scales as predictors the HM, H parts, Sex vs. Emblem, and Mask vs. Blood factors had multiple correlations ranging from .31 to .37 (probability ranging from .005 to .03).

These results seem to indicate that it is the content information of the Rorschach which overlaps with the Kuder. This seems sufficient to account for the modest success of the Rorschach in discriminating occupational groups found by Cooley and Mierzwa (1961), Segal (1954), and others. With the above exception, the Rorschach does not appear to be part of the nomological network defined by the other tests.

There are many things that the above analysis does not tell us about this population of tests; however, it does give us an indication about the extent to which test A contains information (in the Information Theory sense) also contained in test B. It does not tell us whether this information overlap results from redundant items or from logically different, but covarying behaviors. For this we must look to a content analysis of the instrument items. Nor does the above analysis tell us whether or not a test is a "good" test. The suitability of a test depends on the job one is undertaking with it. For this kind of evaluation, we must look to predictive studies with outside criteria. Some of this type of information concerning entrance into scientific careers is provided in the body Scientific Careers Study report.

If we can assume that the strengths of these relationships are not in great part determined by differences in reliability of the instruments, we see that in spite of the differences in the time of administration, the Kuder, SVIB, and AVL form a cluster which might be termed "interests". The instruments measuring environment (Press), ability (CTMM), and temperament (G-Z) are less strongly related to each other and to the interest tests. To speculate for a moment one might picture these domains as they exist in this sample as a continuum of ability, interests, and temperament each related about equally to environment.



This speculation about domains seems to be implicit in much psychometric research, and the above results appear to be consistent with this way of thinking about the components of behavior. The results of the Scientific Careers Study also seem to support this idea of domains of data. At various stages of development attributes peculiar to each of these logical domains play some role in career choice. It would seem to be of extreme value, for example in counseling, to identify the pertinent human attributes at these various levels of the individuals career development.

TABLE B1

CANONICAL CORRELATIONS FOR THE BEST LINEAR COMBINATIONS OF SCALES FOR EACH INSTRUMENT PAIR

Instrument	No. of Scales	Kuder	SVIB	AVL	Press	CTMM	G-Z
1. Kuder	10	---					
2. SVIB	11	.74	---				
3. AVL	5	.53	.74	---			
4. Press	11	.50	.54	.48	---		
5. CTMM	4	.45	.52	.38	.38	---	
6. G-Z	9	.59	.55	.47	.42	.33	---
7. Rorschach	14	.54	.55	.48	.54	.35	.46

TABLE B2

NORMAL DEVIATES FOR THE TEST OF NON-ZERONESS OF THE COMPLETE SET OF CANONICAL CORRELATIONS FOR EACH TEST PAIR

	Kuder	SVIB	AVL	Press	CTMM	G-Z
1. Kuder	---					
2. SVIB	10.09	---				
3. AVL	5.73	8.18	---			
4. Press	2.44	2.40	2.47	---		
5. CTMM	3.11	3.00	1.62	1.76	---	
6. G-Z	4.31	3.60	2.12	1.05	0.33	---
7. Rorschach	2.38	-0.91	0.96	0.68	-0.34	0.15

TABLE B3

PROBABILITIES ASSOCIATED WITH THE NORMAL DEVIATES

	Kuder	SVIB	AVL	Press	CTMM	G-Z
1. Kuder	---					
2. SVIB	10^{-23}	---				
3. AVL	10^{-8}	4×10^{-15}	---			
4. Press	7×10^{-3}	8×10^{-3}	7×10^{-3}	---		
5. CTMM	10^{-3}	10^{-3}	.05	.04	---	
6. G-Z	2×10^{-5}	10^{-4}	.02	.15	.37	---
7. Rorschach	9×10^{-3}	.82	.17	.25	.63	.44

TABLE B4

CANONICAL EQUATION FOR THE RORSCHACH FACTORS (14) VS. THE KUDER SCALES (10)

Canon R	.54	
		$df_1 = 14$
Rao's F Ratio	1.33	
		$df_2 = 1239.9$
Probability	9×10^{-3}	

Factor	Rorschach	Kuder	Scale
1. Animal	-.21	.14	outdoor
2. Nature	-.14	.45	mechanical
3. Clouds, m, mf	-.23	.30	computational
4. Shading	-.09	-.20	scientific
5. Fire, Fm	.07	.23	persuasive
6. Abs. color	.02	-.54	artistic
7. HM	-.30	.09	literary
8. H parts	-.49	.13	music
9. Sex vs. Emblem	.37	.08	social
10. Art	.10	-.53	clerical
11. Furs	-.10		
12. Color	.07		
13. W	-.20		
14. Mask vs. Blood	-.59		

TABLE B5

	Mechanical			Artistic			Clerical		
Mult R	.39			.42			.40		
F Ratio $^{14}/158$	1.98			2.42			2.09		
Probability	.020			.004			.015		
	r	B	t	r	B	t	r	B	t
1. Animal	-.11	-.13	-1.76	.00	-.01		.08	.07	
2. Nature	-.15*	-.17	-2.30	.01	.00		-.07	-.04	
3. Clouds, m, mf	.01	.05		.08	.10	1.36	.08	.05	
4. Shading	-.03	-.03		-.01	-.04		.00	.00	
5. Fire, Fm	-.01	.03		-.02	-.01		-.01	.01	
6. Abs., color	-.16*	-.14	-1.83	-.07	-.09	-1.17	-.06	-.06	
7. HM	.12	.13	1.74	.17*	.16	2.22	.04	.05	
8. H parts	-.15*	-.12	-1.62	.12	.15	2.08	.10	.09	1.18
9. Sex vs. Emblem	-.04	.02		-.25**	-.25	-3.38	.02	-.01	
10. Art	.13	.15	2.01	.19**	.15	2.00	-.15*	.16	-2.16
11. Furs	-.04	-.06		-.06	-.07		.20**	.19	2.59
12. Color	-.11	-.13	-1.72	-.05	-.03		-.10	-.06	
13. W	-.02	-.04		.06	.03		.00	.05	
14. Mask vs. Blood	-.11	-.13	-1.72	.14*	.13	1.76	.26**	.24	3.21

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* $p < .05$
** $p < .01$

APPENDIX C

CAREER DEVELOPMENT OF SCIENCE TEACHERS

by Eugene C. Lee
Associate Professor of Education
Emory University

The problem of providing a sufficient scientific manpower pool to meet current and projected needs in America hasreceived considerable attention in recent years. There is also an increasing interest in the educational process that must take place before an operating scientist or technician takes his place in the manpower pool. While there are several aspects of the science program in the secondary school that should be studied, one of the most important factors is the science teacher. The science teacher influences the nature of the science program in the school and is the initial science contact for most of the pupils who continue on to college and eventually become practicing scientists.

Despite the apparent need for more basic research on science teachers, status studies seem to predominate. These consider such things as hours of undergraduate preparation, teaching assignments, size of classes, number of new teachers needed, and other similar information. There is nothing of the values, interests, or attitudes of these teachers. If variables of that nature were examined, it might be possible to come closer to an explanation of the classroom behavior of a teacher and how it affects the pupils. Obviously, a single investigation could not hope to consider all aspects of science teacher personality and how it affects learning outcomes. The field must be narrowed and the investigation cast into some logical framework so that the results are interpretable.

Data released by the NEA Research Division in 1957 show that 47% of the science teachers come from liberal arts colleges. Primarily, these are students who enter college with an intent to major in one of the sciences and make the decision to enter science teaching during college. This is an interesting group to examine. If a person begins a science major and subsequently changes his career plans, there are possibly identifiable influences causing this change. Also, if almost half of our science teachers are in this category, the sheer numbers make them important.

The developmental approach can furnish some structure for examining this problem. It is possible to consider this future science teacher group as a sub-set of the Potential Scientist Pool (PSP). At some point in their college careers, some members of this PSP make the decision to go into secondary school teaching. A model of this pattern is given below:

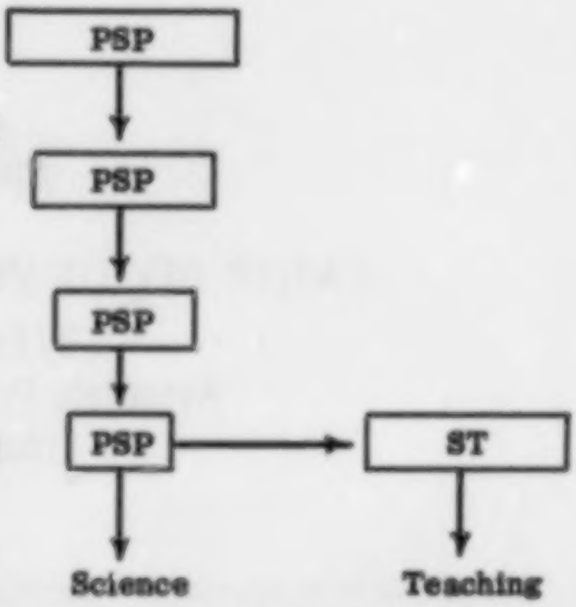
Stage I. The original group is the Potential Scientist Pool (PSP).

Stage II. As this group moves through school the pool shrinks at each decision point; 9th grade curriculum decision, high school graduation, college entrance.

Stage III. At college entrance, the group contains those enrolled in a science major.

Stage IV. During college years a decision is made by some of the pool to enter science teaching and they split off the main group.

Stage V. The final criterion is entry into the field of work, either science or science teaching for our purposes.



This is, of course, an idealized model and not all liberal arts science teachers can be described by this pattern. There are indications, however, that quite a few do follow this course. Studies by Lovelace (1958), Richardson (1958), and others support this pattern. There is an assumption made in the model that should be noted: individuals following the pattern described develop an interest in science before an interest in teaching, and the decision to enter teaching is made after the decision to pursue an area of science.

A comparison of those college seniors who decide to continue in science (PSP) with those who decide to enter teaching (ST), would possibly identify the factors involved in the decision indicated at Stage IV in the above model. That period approximates the exploratory stage as described by Super (1957). This comparison would have two primary advantages. First, the educational background and age of the two groups would be comparable. Secondly, by studying these groups shortly after this decision is made, the groups would not have been socialized by experience in their field of work.

PERSONALITY STEREOTYPES

One of the techniques used in research of this nature is to construct a personality model or stereotype of the groups being studied. While this does not represent any one individual in the group, it is often very useful in deriving dimensions of personality that might be studied profitably. In this instance we can describe some of the personality characteristics that might distinguish the two groups. These characteristics can later be used in formulating hypotheses about differences between the two groups. The stereotype represents a synthesis of the literature on scientists and teachers. Roe's (1957) model of occupational group differences was especially useful.

In general we would expect persons in the science teaching group to be more person-oriented than those in the science group. This trend would be manifest in a personality pattern that was more outgoing, warm and interpersonal. The teacher would have more concern for other people and their problems; he would score higher on social welfare and empathy scales. He would be more comfortable in the presence of others and enjoy personal contacts, whereas the scientist would avoid large groups and personal contact. The teacher would place human values above those of a more objective nature; he is more likely to "win friends and influence people". The scientist would be more objective in his outlook and tend to categorize or synthesize problems. The scientist would tend more toward an interest in things than in people.

By the use of the career pattern model and the personality stereotypes outlined above, the design of this research was established. The general task was to compare the personality trends of two groups of young men, one group entering careers in science and another moving into science teaching.

THE SUBJECTS

1. The scientist group was composed of male science graduates from six local (New England) colleges who had graduated in the spring of 1959 and continued in science (N = 61). This group was drawn from subjects in the Scientific Career Study and is designated the SCS group.

2. The science teacher group was drawn from male liberal arts graduates in science who entered fifth year programs in science teacher training (N = 66). This group is called the Liberal Arts Science Teachers, or the LAST group.

INSTRUMENTS

Three personality instruments were used:

1. The Strong Vocational Interest Blank for Men - hereafter referred to as the "Strong Interest Blank".

2. The Allport-Vernon-Lindzey Study of Values - hereafter referred to as the "Allport-Vernon-Lindzey".

3. The Guilford-Zimmerman Temperament Survey - hereafter referred to as the "Guilford-Zimmerman".

Not all of the scales on these instruments were pertinent to the problem being studied. Certain scales were selected from the three instruments and used in the analysis. The selection of scales and their use in the analysis are discussed below.

PROCEDURE

The testing of the SCS group was done during the 1958-59 academic year. The gathering of test data for the LAST group was begun in the spring of 1960, and continued through the fall semester. Letters were written to colleges that offered programs that might enroll the type of students needed for the LAST group. When information was received that subjects were available for testing, test packets containing all the instruments were sent to the institution for administration. By December 1, 1960, some 85 packets had been returned.

The process of elimination of subjects that either did not meet the criteria or had incomplete data left 66 completed forms that were satisfactory for the LAST group. The SCS group had 100 subjects. Through a follow-up questionnaire sent out the year after graduation more recent occupational information was available on this group. These questionnaires were used to determine those who had graduated as science majors and continued to pursue careers in science. Eliminating those who did not meet this criterion left an N = 61 for the SCS group.

This meant a total of 127 subjects would be included in the study. The groups did however, meet the criteria set up previously and it was felt that some sacrifice in total subjects was justifiable to keep the groups as homogeneous as possible.

HYPOTHESES

Previous research, the career pattern model and the personality stereotype were considered in deriving the hypotheses concerning differences between the two groups. These hypotheses were set up in three stages: the first stage concerned differences between the two groups using all of the selected scales from all three instruments; the second stage was a set of hypotheses concerning differences between the groups on each of the three instruments administered; the third stage was a set of hypotheses concerning each of the selected scales used, not only predicting a difference, but the direction of the difference. The three stages are outlined below:

General: There is no significant difference between the SCS and LAST group using all of the selected personality variables.

Area:

1. There is no significant difference between the SCS and LAST groups on the selected scales on the Strong Interest Blank.

2. There is no significant difference between the SCS and LAST groups on the selected scales on the Allport-Vernon-Lindzey.

3. There is no significant difference between the SCS and LAST groups using the selected scales on the Guilford-Zimmerman.

Scales: On the scales selected, the reason for their selection and the predicted direction are as follows:

ALLPORT-VERNON-LINDZEY

1. Theoretical (Th) - From the description of the scales given in the manual we would expect the SCS group to score higher on this particular scale. "The dominant interest of the theoretical man is the discovery of truth. In the pursuit of this goal he characteristically takes a 'cognitive' attitude, one that looks for identities and differences; one that divests itself of judgment regarding the beauty or utility of objects, and seeks only to observe and reason. Since the interests of the theoretical man are empirical, critical, and rational, he is necessarily an intellectualist, frequently a scientist or philosopher. His chief aim in life is to order and systematize his knowledge." Following the syndrone outline above the hypothesis is:

$$H_1: \text{SCS} > \text{LAST}$$

2. Aesthetic (Ae) - When selecting the Theoretical scale it follows that the scale described as directly opposed to it should be used and the prediction reversed. "The aesthetic attitude is, in a sense, diametrically opposed to the theoretical; the former is concerned with the diversity and the latter with the identities of experience." The prediction on this scales:-

$$H_2: \text{SCS} < \text{LAST}$$

3. Social (So) - If the picture created of the teacher being more person-orientated is to hold up, this scale must be included. "The highest value for this type is love of people. The social man prizes other persons as ends, and is therefore himself kind, sympathetic, and unselfish." The prediction on this scale is:

$$H_3\text{: SCS} < \text{LAST}$$

The three other scales on the Allport-Vernon-Lindzey were not directly concerned with the problem under investigation and were not included for this reason.

GUILFORD-ZIMMERMAN

The Guilford-Zimmerman is partially concerned with measuring interpersonal relations. Four scales were selected as being most likely to measure the type of interpersonal relations which were of interest.

4. Personal Relations (P.R.) - The description of this scale makes it mandatory for inclusion. "Of all the scores, this one has consistently correlated highest with all criteria involving human relations. It seems to represent the core of 'getting along with others', whether on the same or a different level of organizational hierarchy." A high score on this scale shows a tolerance and understanding of other people and their human weaknesses. The prediction on this scale is:

$$H_4\text{: SCS} < \text{LAST}$$

5. Objectivity (Ob.) - This scale is concerned with emotional objectivity and not intellectual objectivity. Previous research indicated the teacher group would be higher. A high score on this scale indicates a person who is "thickskinned" and not so touchy, while a low score indicates a hypersensitiveness and self-centeredness. The prediction on this scale is:

$$H_5\text{: SCS} < \text{LAST}$$

6. Emotional Stability (E.S.) - This scale seemed to fit right into the stereotype of person:non-person orientation. A high score indicates optimism and cheerfulness with a stability of moods and a sense of "getting along" with people. A low score indicates a fluctuation of moods, pessimism, and daydreaming. The prediction on this scale is:

$$H_6\text{: SCS} < \text{LAST}$$

7. Sociability (Sy) - A high score reflects a social person who has many friends and acquaintances and who likes social contacts and activities. A low score indicates a dislike for social contacts, few friends, and shyness. The prediction on this scale is:

$$H_7\text{: SCS} < \text{LAST}$$

STRONG INTEREST BLANK

The Strong Interest Blank may be scored in many different ways. The method used here was to score for 11 different occupational groupings. These 11 different groups are derived from scores on the 400 responses given on the Strong. Five of the 11 scales were selected for the study.

8. Group II - Technical Workers (T.W.) - This group includes Chemists and Engineers, and we would expect the SCS group to be higher on this scale. The prediction for this scale is:

$$H_8: \text{SCS} > \text{LAST}$$

9. Group V - Welfare Worker (W.W.) - This group includes people who are in constant contact with the public, such as ministers and teachers. Prediction on this scale:

$$H_9: \text{SCS} < \text{LAST}$$

10. Group VI - Musical Performers (M.P.) - This scale was included out of curiosity. Previous research has indicated that there might be a difference in the avocational interest of scientists and other groups. This finding was supported slightly in a pilot study. The prediction on this scale is:

$$H_{10}: \text{SCS} > \text{LAST}$$

11. Group VIII - Business Detail (B.D.) - This would indicate a stronger dislike on the part of the SCS group for detailed clerical work. Prediction on this scale:

$$H_{11}: \text{SCS} < \text{LAST}$$

12. Group IX - Business Contact Workers (B.C.) - This scale was included in this study because teachers would be expected to be more willing to make contact with people. The LAST group would therefore be higher on this scale.

$$H_{12}: \text{SCS} < \text{LAST}$$

It should be noted at this point that the selection of these scales and the prediction of their direction of significance was made prior to the actual analysis of the data.

ANALYSIS AND RESULTS

The purpose of the general analysis was to test the over-all validity of the personality stereotype. The multivariate test used here determines if the two groups differ significantly on the combined twelve variables. If over-all differences between the SCS and LAST groups are significant, we can conclude that the stereotype in general is not invalid.

One assumption underlying the multivariate analysis of group mean differences is the homogeneity of dispersions of the two grups. A test of this assumption was accomplished by using Box's (1949) generalized test of homogeneity of variance. This analysis tests the difference in dispersions between the two groups (in the twelve dimensional space) and is sometimes referred to as H_1. The result obtained in this test was:

$$\text{test of } H_1\text{: Box's } M = 91.53 \qquad F^{78}_{48,700} = 1.05 \qquad p = .30$$

Since the difference in dispersions was not significant, we can assume the two groups are from populations with a common dispersion.

Having satisfied the assumption of homogeneity of dispersions, the question of differences among the group means on the variables selected was examined.

TABLE C1

A SUMMARY OF THE ANALYSES PERFORMED ON THE 12 INDIVIDUAL VARIABLES WITH THE PREDICTION AND OUTCOME OF THAT PREDICTION

AREA	VARIABLE	PREDICTION	t	p	HIGH GROUP	OUTCOME OF PREDICTION
G - Z	Social	SCS < LAST	2.373	$p < .01$	LAST	Correct
G - Z	Emotional Stability	SCS < LAST	2.589	$p < .01$	LAST	Correct
G - Z	Objectivity	SCS < LAST	1.657	$.025 < p < .05$	LAST	Correct
G - Z	Personal Relation	SCS < LAST	2.013	$.01 < p < .025$	LAST	Correct
A - V - L	Theoretical	SCS > LAST	1.174	not significant	SCS	No difference
A - V - L	Aesthetic	SCS < LAST	.825	not significant	SCS	No difference
A - V - L	Social	SCS < LAST	3.865	$p < .0005$	LAST	Correct
Strong	Tech. Worker	SCS > LAST	3.946	$p < .0005$	SCS	Correct
Strong	Welfare Worker	SCS < LAST	6.379	$p \quad .0005$	LAST	Correct
Strong	Musical Perf.	SCS > LAST	.720	not significant	LAST	No difference
Strong	Business Detail	SCS < LAST	.748	not significant	SCS	No difference
Strong	Business Contact	SCS < LAST	.454	not significant	LAST	No difference

The test of the equivalence of mean vectors is sometimes referred to as H_2. The results were as follows:

Test of H_2: Wilks' lambda = .614 $\quad F^{12}_{124} = 6.502 \quad p < .001$

This indicates that the scientist and science teacher groups have over-all differences on the twelve dimensions included in the above analysis. The hypothesis that the two groups are not random samples from a common multivariate population is tenable.

INDIVIDUAL VARIABLE ANALYSIS

The final step of the analysis was to test the significance of each of the selected variables. First, a test of homogeneity of variance was performed on each variable. If the null hypothesis of no difference could not be rejected, then a one-way t test for independent means was made. The homogeneity of variance assumption was tenable for all twelve scales. Table C1 presents a summary of the 12 variables, their predictions and outcome. Eight of the twelve variables selected were significant in the direction predicted. On the other four selected variables no significant differences were found.

The results confirm the hypothesis of teachers versus "non-people-oriented" scientists. Examining the results for all twelve scales given in Table C1, the LAST group scored higher on all scales involving interpersonal relations. Especially large differences were found for the Social scale on the Allport-Vernon-Lindzey and the Welfare Workers group on the Strong Interest Blank. Both of these scales are "people-oriented" scales. Conversely, the SCS group scored higher on the Theoretical scale on the Allport-Vernon-Lindzey and the Technical Workers group on the Strong Interest Blank. Both of these scales are "non-people-oriented". These results support the personality stereotype which was used in deriving the hypotheses. We can therefore conclude that the science teacher is more like those groups with a major orientation toward persons, as our stereotype model predicted.

SUMMARY AND IMPLICATIONS

The purpose of this investigation was to examine certain personality factors associated with individuals entering science teaching as a career. This was done by comparing a group of individuals entering scientific occupations with a comparable group entering science teaching. Two major difficulties have been encountered in this type of research in previous studies. The first concerns the make-up of the groups themselves. This problem is cited by Super and his associates (1957):

> Individual case histories must be studied in order to understand the effect of various determinants upon individual work careers. Groups must be studied to identify common determinants of career patterns. However, differences in the importance of various determinants could be obscured by the pooling of data from groups which are too heterogeneous. To clarify the roles of determinants, it may be most appropriate to study groups with certain characteristics in common and to compare such groups with other groups having different characteristics in common.

In designing this research, care was taken to insure that the two groups were as comparable as possible on control variables. Both groups consist of male science graduates from liberal arts colleges within the last two years. The complete report of this investigation gives evidence as to the similarity of the two groups on variables other than the particular dependent variables (scientist: science teaching) and independent variables (personality dimensions) under investigation.

The second problem with much of the previous research has been in the handling of the data. Again from Super:

> A serious problem in this area of vocational research stems from the lack of an adequate methodological model for the analysis of career patterns. . . In order that such psychological factors as aptitudes, interests, intelligence, values, and personality characteristics may be represented in the career pattern, the model must be necessarily expanded into n-dimensional space.

This problem has been attacked in this research though the use of multivariate methods of analysis, and through the use of high speed computers which make this approach practical. This allows the investigator to consider all of the variables in combination at one time instead of the previous method of one or two at a time.

The focus of this study was in one sense rather narrow. This was intentional. There are many influences which are involved in shaping a career over a period of time. It would have been impossible to study all of them. By choosing one area of influence, one period of time and one occupational group, the problem becomes manageable. The general area of influence chosen was personality (broadly defined), the period of time was the Exploratory Stage (as defined by Super, 1957) and the group chosen was science teachers. The results of the analysis substantiated this choice. Approximately 39% of the variance in the choice process studied here is explainable in terms of the personality factors studied. This is a considerable portion for any one system of influence, and justifies the approach used in this study.

A major concept used in designing the research was the career pattern model outlined at the beginning of this report. This model described the progression of the science teachers in a similar pattern to that of a scientist up to a period in their college career. During this college period the science teachers made the decision to move out of science per se and into science teaching. This model was used in designing the research and selecting the groups. From the background questionnaire it was determined that 3/4 of the subjects in the LAST group either followed or approximated closely this pattern. The remaining 1/4 differed only in the timing of the decision, either before or after the period selected for study (Stage IV in the model).

From the favorable results of the analysis it can be assumed that this model is a useful one. This concept has implications for guidance activities at both the high school and college level. Since a good proportion of science teachers follow this pattern or a similar one, caution should be used in "advising" students who are "people-oriented" out of science at the high school level. One of the assumptions stated in connection with the model was that an interest in science preceded an interest in teaching. Quite possibly this interest in teaching or working with people does not manifest itself until late in the college career. If we wish to produce science teachers with a strong background in subject matter it might be wise to encourage these people to pursue their science interest. However, at the college level when a decision is made definitely not to pursue a career in science then the possibilities of teaching could be presented to the student.

The results reported in this research could also be of use in the screening and selection of candidates for fifth year programs in teacher training. Present tendencies are to use academic records or Graduate Record Examination scores as the major criteria for admission. This research indicates that there are clearly identifiable personality traits associated with individuals entering science teaching from science backgrounds. A battery of tests such as those used in this study could be used to indicate those individuals who deviate markedly from the norms for the group. Many of the problems encountered with students in fifth year programs are caused by personality difficulties rather than academic ones.

The second major concept used in the research design was a personality stereotype. This was a description of the major tendencies of the two groups with the science teacher being more involved with people and interpersonal contacts, while the scientist tends toward avoidance of interpersonal contact. The outcome of the analysis indicates that this stereotype is a good approximation and useful in thinking about the two groups. This concept has meaning for those concerned with the training of science teachers. Advantage should be taken of this "people-orientation". Instead of the emphasis in a methods course on "how-to-do-it", it might be more profitable to emphasize human relations. "How-to-relate-it" to the learners and what meaning does it have for the learners might be a profitable approach to use. The idea of using personality information in working with teachers both pre-service and in-service is one that needs further exploration.

APPENDIX D

THE RELATIONSHIPS AMONG BIRTH ORDER, DIMENSIONS OF INDEPENDENCE,- DEPENDENCE AND CHOICE OF A SCIENTIFIC CAREER

by

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BACKGROUND

A factor reported to be significant in studies of the scientist's background is his birth order position. Super and Bachrach in their 1957 review and critique of the literature on natural scientists noted that this scientific career – birth order relationship has been treated in a static manner. They concluded that since the scientist's position in the family has been shown to be a factor, the dynamics of family relations in terms of birth order should be studied.

This investigator's analysis of the literature in this area indicated that the relationship between choice of a scientific career and birth order position is not as clearly established as Super and Bachrach have suggested. There did seem to be a trend in these studies for the scientist to be the first born. Occasionally he was also found to be the eldest son or only son or the fifth or sixth in the birth order. However, certain statistical assumptions and methods in these studies forced one to conclude that these findings still remained to be proved statistically significant. The absence of adequate control groups prevented us from knowing whether the posited relationships were unique to the scientific occupations or part of a more inclusive group trend. Some of these studies included small numbers of social scientists in their samples or dealt only with eminent scientists and this raised questions about these findings in terms of the general natural science and engineering population. Is birth order related to choosing a career involving the subject matter of natural science and/or engineering, the desire to do research irrespective of the subject matter or the choice of a scientific research career?

If the trend for the scientist to be first born were substantiated statistically, it would then be appropriate to explore factors which could be involved in this relationship. Career choice is a complex process involving many factors over a period of time. A direct causal relationship between any single factor and choice of a scientific occupation would not be expected. This is particularly true in terms of the birth order variable which is merely a descriptive category. Nevertheless, it may be related to variables which can be meaningful in helping us to understand the tendency for the scientist to be first born. If the relationship were substantiated it would not be possible to explain why certain first borns become scientists but we would beable to look for factors which may be relating the 2 groups and thus, add more parameters to the description of our scientific population.

Information about scientists as a group indicated that an outstanding characteristic of the scientist is his desire and need for independence.

The research reported in this Appendix was conducted by Dr. Susan G. Krinsky as a doctoral investigation. It is being reported here because it was supported in part by the Scientific Careers Study. For a more complete description, see Krinsky (1963).

Some of the theoretical literature suggested that the first born would tend to be independent but much experimental evidence indicated that first borns were more dependent than later borns. Certain qualifications of these findings are necessary, however, in terms of the types of independence and dependence measured and conditions under which the individual functioned.

If the scientist tends to be independent and first borns tend to be dependent there might appear to be a contradiction when this is related to the finding in the literature that the scientist tends to be first born. Perhaps this can be understood by suggesting that those first borns selecting scientific careers are among other things more independent than the average first born.

Another explanation of this apparent contradiction may be that the studies of scientists and the birth order studies are measuring different types of independence and dependence, in different ways and under a variety of conditions. There was a need to study the same dimensions of independence and dependence in a well defined sample analyzed interms of birth order and career choice variables. Since the original data collected for the main part of the Scientific Careers Study were insufficient to explore these questions, additional data were obtained and analyzed. This Appendix describes the parallel investigation.

DESIGN AND PROCEDURES

This was a 2 part study. Part I was designed to investigate whether or not birth order was related to choice of a scientific career, a research career (irrespective of subject matter) or a scientific research career. Part II was designed to investigate whether 4 dimensions of the domain of independence-dependence-autonomy, deference, nurturance and succorance were among the variables mediating a relationship between birth order and a choice of a scientific career, a research career, or a scientific research career. In both Parts I and II the research career and subject matter-research career variables were analyzed generally and then further analyzed in terms of the emphasis on research: research emphasis (with or without some teaching) or teaching emphasis with some research. In Part II administration emphasis with some research (with or without some teaching) was also included.

PART I

A scientist was defined in Cooley's terms as "an individual who is practicing a vocation which necessitated at least 4 years of college training in 1 or more of the natural sciences or engineering." An individual was considered to be a researcher if he was engaged in the search for and production of new knowledge. Research engineers involved in development were included in the researcher category. However, in order to be classified in the researcher category the subject must have intended to obtain a doctorate in his field of engineering.

A questionnaire was constructed for the study upon the basis of which subjects were classified in terms of birth order and career choice variables. It also provided information which allowed the groups to be compared in terms of the subject's age, parents' ages and father's socio-economic status.

The final sample used in the analyses was drawn from those subjects who responded to a mailed questionnaire and who met the necessary criteria.

In selecting the initial sample to whom the questionnaire was to be sent it was necessary to find subjects who could be classified into 1 of 4 occupational categories: science research, science non-research, non-science research, and non-science non-research. The initial sample consisted of 822 subjects. It was thought that it would not be possible to obtain the participation of men well established in the science and non-science research fields. Therefore, male doctoral candidates were selected who had completed at least 1 year of graduate work and were making a full time commitment to graduate programs the goals of which were to train researchers. The science research group (N = 211) was composed of doctoral candidates at Harvard University and M.I.T. in the fields of biology, chemistry, physics (theoretical and applied), and engineering—chemical, civil, electrical and mechanical. The non-science research group (N = 196) consisted of Harvard doctoral candidates in the disciplines of classics, economics, fine arts and history.

The science non-research group (N = 207) was drawn from lists of 1958 and 1959 graduates of the Northeastern University College of Engineering who had majored in the same engineering disciplines as the graduate group. The non-science non-research group (N = 208) consisted of 1958 and 1959 accounting major graduates of the Boston University and Northeastern University Colleges of Business Administration. This group also included master's degree candidates in the areas of control and finance at the Harvard Graduate School of Business Administration.

The questionnaire was mailed to the subjects and written and telephone follow-ups were conducted with those subjects who did not respond spontaneously. Five hundred and fifty-four questionnaires were returned completed.

The final science and non-science research groups consisted of those who planned to obtain a doctorate and to do some research. Subjects were included in the science non-research and non-science non-research groups on the basis of their (1) working in the appropriate field, (2) not planning to obtain a doctorate, (3) not planning a research career.

Subjects were excluded from the final sample if they had incomplete or complicated family situations which might have contributed bias to the study (stillborn or deceased sibs, separated or divorced parents, adopted or foster sibs, etc.).

The final sample consisted of 310 subjects; 113 in the science research group, 59 in the science non-research group, 80 in the non-science research group, and 58 in the non-science non-research group.

The subjects were classified in terms of 13 birth order and sibship structure classification systems which were based upon the following factors individually or in combination: chronological birth order position, psychological birth order position (only child, eldest child, only son, youngest child, etc.) size of the sibship, sex composition of the sibship, sex of and age distance to the next eldest sib, and sex of and age distance to the next youngest sib.

The career classification systems were based upon subject matter (science and engineering vs. non-science or science vs. engineering vs. non-science), research vs. non-research orientation, research emphasis or teaching emphasis with some research, and combinations of the subject matter and research classifications.

One hundred and eighty-one chi square analyses were conducted in terms of combinations of the birth order and career choice classification schemes.

PART II

Independence-dependence was conceived of as a multi-dimensional domain each dimension of which was bipolar and labeled in terms of directionality. Dependence was thought of as the extent to which the individual uses or relies on other persons as sources of approval, support, help and reference. Independence was considered to be its converse. The 4 dimensions of independence-dependence studied in this investigation were defined and measured in terms of the autonomy, deference, nurturance and succorance scales of the Edwards Personal Preference Schedule.

Of the 310 subjects employed in Part I, the Edwards Personal Preference Schedule was mailed to the 289 who could be reached. After written and telephone follow-ups 184 questionnaires were returned completed and 159 met our standards of reliability.

The subjects had already been classified according to birth order and sib structure variables and career variables in Part I. Discriminant analysis was used as a generalized test of analysis of variance to determine whether the birth order or career choice groups differed in terms of their patterns of scores on the 4 dimensions. The discriminant analysis program also yielded individual F ratios of 1-way analyses of variance. In addition to this 48 2-way analyses of variance interms of the 4 dimensions of independence-dependence were conductod with birth order and career classification schemes.

Summary of Results and Conclusions

PART I

It might be helpful to summarize the results and conclusions in terms of the questions which were initially posed.

QUESTIONS CONSIDERED

1. Is there a relationship between a subject's choice of a scientific career and his chronological birth order position-particularly being the first born (only child and/or eldest child)?

   No relationship was found between the subject's choice of a scientific career and his being first born (only and eldest children combined or separate) or any other unqualified chronological birth order position.

2. Is there a relationship between the subject's choice of a scientific career and his psychological birth order position— particularly being the eldest child, only child, eldest son or only son?

   No relationship was found between the subject's choice of a scientific career and his psychological birth order position.

3. Are there qualifications in the chronological birth order position or psychological birth order position in terms of size of sibship, sex composition of the sibship, the sex of and age distance to the subject's next eldest and youngest sibs, which affect the relationship with career choice of science?

A trend was found in which more scientists and engineers than would have been expected by chance had as the next eldest sib a sister 0 through 2 years older and significantly more non-scientists had as the next eldest sib a brother 5 or 6 years older.

It was also found that there were significantly more non-scientists than scientist and engineers who were second born and whose next eldest sib was 5 or more years older. There were significantly more scientists and engineers than non-scientists who were third or later born whose next eldest sib was 0 through 2 years older.

Another analysis revealed that more scientists and engineers than would have been expected by chance had a sister as the next youngest sib.

In spite of these results the investigator believes on the basis of statistical considerations and the lack of relation of these findings to theoretical or empirical evidence that the results may very well have been due to random error, and thus may not be meaningful.

4. Is chronological birth order position or psychological birth order position related to choice of a career involving (a) the subject matter area of science (natural and/or engineering) or (b) the process of research irrespective of the subject matter or (c) research only in the area of science?

   Those analyses which were significant (specific results were described in question 3 above) indicated a relationship between the variables of sex and age distance to the next eldest sibling and the choice of a career involving the subject matter categories of science and engineering vs. non-science. Chronological birth order position and age distance to the next eldest sib were also found to be related to the subject matter categories both when the scientists and engineers were analyzed separately or combined in the comparison with the non-scientists. The variable of the sex of the next youngest sib was found to discriminate between the subject matter groups when the scientists and engineers were combined and compared with the non-scientists.

   None of the classifications involving the research groups or the subject matter-research groups yielded significant results in terms of any of the birth order variables.

5. Are there qualifications of the career variables, in terms of the various disciplines within the areas of science and non-science or different degrees of commitment to research which are related to the chronological birth order position, or the psychological birth order position or of other sib structure positions of the subject?

   Unfortunately there were not enough subjects to do refined analyses of birth order relationships among the various disciplines within thee major subject matter categories of science and non-science.

   These analyses of the birth order variables and the 3 categories of commitment to research — research emphasis with or without some teaching, teaching emphasis with some research, and no research were not found to be significant.

In conclusion, it may be said that the relationships between birth order and choice of a scientific career previously reported in the literature have not been substantiated by this study. This investigation approached the birth order variable as an index to a complex, dynamic situation which should be studied. The numerous classification systems of both the birth order and the career variables and the use of control groups should have maximized the possibilities of discovering relationships between these variables. It must be noted that some statistically significant trends were observed but since such a large number of analyses were conducted one cannot place much confidence in them. The "significance" may have been due to chance. If similar results can be obtained again with another sample and if some plausible hypothesis can be derived to explain their occurrence one might have more faith in them. On the basis of this study, however, the investigator concludes that at present the existence of a relationship between an individual's choice of a scientific career and his chronological birth order position (qualified or unqualified) is seriously in question.

The size of the sample should be mentioned as a limitation of this study. In order to eliminate factors which might have contributed bias or would have made it more difficult to hypothesize about what might be operating to bring about significant relationships, it was necessary to exclude a large number of subjects from the study. It is felt that this was a wise decision. However, it is suggested that future studies dealing with this topic should employ a very large number of subjects. This would not only permit more refined analyses but would increase the confidence with which one could consider relationships which might be found.

PART II

In terms of the 4 dimensions of independence-dependence under consideration:

1. Are there differences among members of different birth order and sib structure categories (classified according to schemes used in Part I)?

   The only children, eldest children and non-first borns differed in terms of their responses to the 4 dimensions. The trends indicated that only children were the most autonomous, the least deferent and nurturant but the most succorant. Non-first borns were the least autonomous and the most deferent and nurturant. Although they were less succorant than the only children they were more succorant than the eldest children. It was found that first borns (both only and eldest children) were more autonomous than later borns but within the first born category, only children were slightly more autonomous than eldest children. When chronological birth order position was analyzed in terms of the subject's needs for autonomy it was learned that the later born a subject was the less need for autonomy he had.

   Subjects were also found to vary in their patters of responses to questions about needs for autonomy, deference, nurturance, and succorance according to the age distances to their next youngest sibs. Two interesting patterns emerged. The group which was 3 or 4 years old when the next sib was born had the greatest need for autonomy, was low in deference and scored the lowest of all groups in nurturance and succorance. A shift from this independent orientation found in the 3 through 4 years age distance group toward a more dependent orientation was observed in the subjects who were 5 or 6 at the time the next sib arrived. These subjects score very low in autonomy, high in deference and nurturance and highest of all the groups in need for succorance. Although the 7 or more years category was almost as low in autonomy, these subjects were less deferent, nurturant, and much less in need of succorance than the 5 through 6 year group. The youngest children who of course have no younger sib were the least autonomous of all groups and were quite high in nurturance and relatively high in succorance. The other group which had no younger sib, the only children, was second only to the 3 through 4 year distance group in autonomy and were least deferent, fairly low in nurturance and second highest in succorance. The 0 through 2 year group was fairly high in autonomy, highest in deference and nurturance and low in succorance.

The subjects were classified according to both age distance to and sex of the next youngest sib in a 1-way analysis of variance. Regardless of the sex of the younger sib the subjects who were 3 or 4 when that sib arrived were still the most autonomous. Those with a younger brother tended to be slightly (.77) more autonomous than subjects with a sister 3 or 4 years younger. This trend was also observed to a lesser degree (.19) in the 0 through 2 year age distance group but it was reversed when the sib was 5 or 6 years younger and 7 or more years younger. Under these circumstances it appeared that the sex of the younger sib as well as the increase in age distance from the sib seemed to be related to the subject's need for autonomy. In both of these groups subjects with a younger sister were more autonomous than those with a younger brother. It seemed that after the 3 through 4 year peak period as the distance between the sibs became greater the effect of the sex of the younger sib on the subject's autonomy score increased. Those with sisters 5 or 6 years younger scored 1.17 higher on autonomy than subjects with brothers that much younger. When the distance to the younger sib was 7 or more years, those with younger sisters were 2.87 higher on autonomy. The difference became more dramatic when it was noted that of the 10 groups, subjects who had sisters 7 or more years younger ranked third in autonomy (both of the 3 and 4 year groups ranked higher) but the group which had brothers 7 or more years younger ranked tenth or lowest in autonomy. A 2-way analysis of variance of the relation of the sex of the younger sib and the subject's age distance to the younger sib on autonomy yielded neither main nor interaction effects. These results appeared to be due to sampling fluctuation when 66 cases were dropped for sell proportionality purposes.

It was also found that subjects differed in needs for succorance in terms of the age distance to their next youngest sibs. Those who were 5 or 6 when the new sib arrived were the most succorant. There was much less need for succorance in the group which had sibs 7 or more years younger. Those subjects having no younger sibs, the only children and youngest children, were second and third highest in need for succorance. The 3 through 4 year age distance group was the least succorant. When the sex of the younger sib as well as the age distance was taken into consideration, it appeared that in all categories excepting the 3 through 4 year group the subjects with younger brothers were more succorant than those with younger sisters. The difference in succorance scores between those who had sisters and those who had brothers 3 or 4 years younger was only .15 whereas in the other age distance categories the sex differences ranged from 1.17 to 2.56. A 2-way analysis of variance of the relation of the sex of the younger sib and the subject's age distance to the next youngest sib in terms of succorance yielded no significant results but this may have been due to sampling fluctuations.

A 2-way analysis of variance indicated that subjects with sibs 3 or 4 years younger were also the least nurturant. Only children were the next lowest in nurturance but the other group with no younger sib, the youngest children, was the most nurturant. The expansion of this classification schems to include sex as well as age distance did not yield significant differences among the groups.

Subjects were also found to differ on autonomy in terms of age distance to the next eldest sib. Those with no older sibs (first borns) were the most autonomous. As the distance to the next eldest sib increased the need for autonomy decreased.

2. Are there differences between scientists (and/or engineers) and non-scientists?

Scientists and engineers were compared with non-scientists (irrespective of research orientation) but the 2 groups did not differ significantly in their response patterns on the 4 dimensions of independence-dependence or in terms of needs for the variables individually.

When, however, scientists and engineers were separated and compared with non-scientists the 3 groups differed (.02> p> .01) in terms of the 4 variables. The engineers were the least autonomous, nurturant and succorant and the most deferent. The scientists were the most autonomous and the least deferent while the non-scientists were the most nurturant. The only individual variable on which the groups differed significantly was succorance. Engineers were least succorant while scientists and non-scientists scored almost identically on this variable. The differences among the 3 groups in nurturance were found to be significant in the 2-way analysis of variance. The engineers were again the least nurturant and the non-scientists were only slightly more nurturant than the scientists.

3. Are there differences between researchers and non-researchers?

The general research group consisting of those subjects who intended to obtain the doctorate degree and planned careers in which they would be doing some research, did differ significantly (.02 >p> .01) from the non-research group in terms of the 4 variables.

The researchers tended to be more autonomous, nurturant, and succorant than the non-researchers but only slightly more deferent. The only variable which was significant individually was autonomy.

a. Are there differences among subjects who plan to emphasize research (with or without some teaching), emphasize teaching with some research, and non-researchers?

The general research group was subclassified in terms of research emphasis — those who planned to emphasize research and those who planned to emphasize teaching with some research. When these 2 groups were compared with the non-research group it was found that the 3 groups differed significantly in their responses to the 4 dimensions of independence-dependence (.005 >p> .001). The research emphasis group was most autonomous and the non-researchers were the least autonomous. The teacher-researchers were the most deferent, nurturant and succorant. The non-researchers scored the lowest on these variables and the research emphasis subjects scored between the teacher-researchers and the non-researchers on the variables of deference, nurturance and succorance. Although none of the 1-way analyses of variance indicated that any of the 4 variables could discriminate between the groups individually, a 2-way analysis of variance found support (.05 > p > .02) for the trend observed in autonomy. The research emphasis group was most autonomous and the non-researchers were the least autonomous. A 2-way analysis of variance revealed that the teacher-researchers were the most deferent and the research emphasis group was the least deferent.

b. Are there differences among subjects who plan to emphasize research, emphasize teaching with some research, emphasize administration with some research (with or without some teaching) and non-researchers?

Administrator-researchers were added to the previously mentioned research emphasis analysis and the 4 groups differed on the 4 variables (.005 >p> .001). The administrator-researchers were the least autonomous of the research groups but still were more autonomous than the non-researchers. They scored lower than all the other groups including non-researchers on the variables of deference, nurturance, and succorance. Nurturance became significant individually when the administrator-researchers were added to the research emphasis analysis.

4. Are there differences among researchers and non-researchers who are scientists and non-scientists?

Science and non-science researchers (general groups) and science and non-science non-researchers did differ in their response patterns on the 4 dimensions of independence-dependence. Succorance was the only individual variable on which they differed significantly. The non-science, non-researchers were found to be the most succorant of the 4 groups while the science non-researchers were the least succorant. There seemed to be only a very small difference in succorance between the 2 research groups. The small trend indicated that the non-science researchers were more succorant than the science researchers.

It has been noted earlier that the general research group was more autonomous than the non-researchers. When these groups were further classified on the basis of subject matter interest there appeared to be little difference between science and non-science researchers and only a minor difference between science and non-science non-researchers as far as autonomy was concerned. The researchers irrespective of subject matter were more autonomous than the non-researchers but in both the research and the non-research groups there was a slight tendency for the scientists to be a little more autonomous.

Although the trend was not significant in the 1-way analysis of variance of nurturance it did seem to indicate that subject matter interest played a more important part with respect to that variable. The non-science researchers were the most nurturant and the non-science non-researchers were second. The science researchers scored closer to the non-science groups than they did to the science non-researchers who were the least nurturant of all.

a. Are there differences among scientists and non-scientists who plan to emphasize research (with or without some teaching), emphasize teaching with some research and those who are non-researchers?

The 6 group differed significantly in the patterns of their responses to the 4 variables. The addition of the subject matter differentiations within each research category resulted in the variables of nurturance and succorance becoming significant individually.

In relation to autonomy it again appears that subject matter differences within research categories were small. The slight trend in which scientists were a little more autonomous than their non-scientific counterparts in the same research category was also found to be operating in this analysis. The largest difference between subject matter groups at the same research level occurred in the teaching-research group. Science teacher-researchers were .39 more autonomous than non-science teacher-researchers. The differences between the subject matter groups on autonomy were, of course, very small but a consistent trend did seem to exist.

Non-science teacher-researchers (the most deferent group) and non-science researchers tended to be more deferent than their scientific co counterparts but the reverse was true in the non-research group.

The science teacher-researchers who were the most nurturant group were the exception to the pattern in the research emphasis and non-research groups in which the non-scientists appeared to be more nurturant than the scientists. Also in this significant 1-way analysis of variance the non-science researchers were more nurturant than the non-science teacher-researchers. This is the reverse of the trend found in the research emphasis analysis irrespective of subject matter, in which teacher-researchers were more nurturant than researchers.

The significant 1-way analysis of variance of succorance indicated that at all levels of research emphasis and non-research categories the non-scientists were more succorant than the scientists. Non-science researchers were the most succorant. (They were also the most nurturant group.) Science teacher-researchers, however, were more succorant than science researchers.

b. Are there differences among scientists and non-scientists who plan to emphasize research, emphasize teaching with some research, emphasize administration with some research (with or without some teaching), and non-researchers?

The responses of the 8 groups to the 4 variables differed significantly. Only the succorance variable was significant individually.

With regard to autonomy, the administrator-researchers reversed the trend observed in the other research level groups which indicated that there was a slight tendency for the scientists to be more autonomous than non-scientists. The science administrator-researchers (who scored only .03 higher than the science non-researchers) were 1.83 less autonomous than non-scientist administrator researchers. They scored the lowest of all groups on deference but were somewhat more nurturant than the non-science administrator-researchers and still more succorant than that group. The latter group was the least succorant of all groups including the science non-researchers.

5. Are there interaction effects among the individual's birth order category or sib structure position (classified according to schemes used in Part I), his choice of a scientific career and/or his choice of a research career?

There were no interaction effects in the autonomy or nurturance analyses.

Deference scores analyzed according to the subject's age distance to the next youngest sib were not significantly different. Subjects did differ on deference in terms of whether or not they chose a research emphasis career, a teaching-research career or a non-research career. When subject's deference scores were analyzed in terms of both age distance to the next youngest sib and career choice emphasis the interaction effect was significant. The significant main effect indicated that the teacher-researcher group was the most deferent. The non-researchers were the next highest and the researchers were the least deferent. However, those researchers who were youngest were more deferent than the non-researchers and the teacher-researchers who were the least deferent among the youngest children. In the 0 through 2 year distance group the researchers were slightly more deferent than the non-researchers. The most deferent of all were the teacher-researchers who had a sib 5 or more years younger but the least deferent were the researchers who had a younger sib at that same distance.

The intereaction effect was significant in an analysis of succorance in terms of the subject's age distance to the next youngest sib and his choice of a career in science, engineering or non-science. Since the main effect of age distance which was significant in the 1-way analysis was not significant here and no meaningful pattern could be found in the interaction little confidence can be placed in these results. They were probably due to sampling fluctuations when the size of the sample was reduced for the 2-way analysis.

Conclusion: Part I and Part II

The investigation, reported in this appendix, was undertaken for 2 purposes: first, to determine whether or not birth order was related to a choice of a scientific career as has been reported in the literature; secondly, to investigate whether 4 dimensions of independence-dependence — autonomy, deference, nurturance, and succorance, were among the variables mediating a relationship between birth order and choice of a scientific career.

A complex of birth order variables was approached in this investigation as an index to a dynamic situation which should be studied. The numerous classification systems of both the birth order and the career variables and the use of control groups should have maximized the possibility of discovering relationships between these variables. The results of Part I of this study did not substantiate the relationships previously reported in the literature. Some other statistically significant trends were observed but for statistical reasons and because no meaningful pattern could be found little confidence was placed in these results. It is concluded, therefore, on the basis of this investigation that at present it is doubtful that a relationship exists between a subject's choice of a scientific career, a research career, or a scientific research career and his qualified or unqualified chronological or psychological birth order position.

Although a birth order and scientific career choice relationship was not substantiated the relation of each to the 4 dimensions of independence-dependence and their possible interactions remained to be studied.

In Part II differences in the dimensions of independence-dependence were observed among subjects classified according to various birth order and career choice systems. First borns (only and eldest children) were found to be more autonomous than later borns. The need for autonomy decreased as the chronological birth order position of the subject increased. Although the only children were slightly more autonomous than the eldest children there was a large difference between these 2 groups of first borns in terms of needs for succorance. The only children were the most succorant of the 3 groups (only children, eldest children, non-first borns) while the eldest children had the least need for succorance.

Some interesting relationships were observed between the subject's age distance to his next youngest sib and his independence-dependence needs. Those subjects who were 3 or 4 years old when the next sib arrived were found to be significantly more autonomous and less in need of succorance than subjects at other age distances or those with no younger sibs. There was also a trend for them to be low in deference and the least nurturant. The arrival of a new sib during this age period seems to be a critical event with respect to the subject's expressed needs for independence as an adult.

A shift from the independent orientation observed in subjects with sibs 3 or 4 years younger toward a more dependent orientation was found in the group which was 5 or 6 when the next sib was born. These subjects scored second lowest in need for autonomy, high in deference, relatively high in nurturance and had the greatest need of all groups for succorance. Those with sibs 7 or more years younger also scored low in autonomy but were less deferent and nurturant than the 5 through 6 year group. The great need for succorance observed at the 5 through 6 year group. The great need for succorance observed at the 5 through 6 year age distance decreased sharply if the new sib arrived when the subject was 7 or older.

There was also some indication that the sex of the new sib was an important factor at certain age distance periods. Trends suggested that in the 5 and 6 year old group and the 7 years and older group the sex of the younger sib was related to the subject's need for autonomy. Those with younger sisters were more autonomous than those with younger brothers. In terms of needs for succorance it appeared that at all age distances excepting the 3 through 4 year category those with younger brothers had greater needs for succorance than subjects with younger sisters. Subjects who were 5 or 6 at the time either a brother or sister was born had greater needs for succorance than any of the other groups but within that group those with a younger brother had a greater need for succorance from others. Some speculations in terms of developmental psychology and psychoanalytic theory were offered (Krinsky, 1963, p. 198-212) as possible explanations of these findings and those previously mentioned but much work remains to be done in this area.

Two comments should be made with respect to the birth order results. First, it is of interest that these birth order and sib structure differences in independence-dependence have appeared in adults. This adds weight to the argument that birth order and sib structure positions are indexes to certain psychologically consistent situations which have lasting effects on the personality regardless of the idiosyncratic nature of the individual's family relationships and learning experiences.

Secondly, since the subjects responded to a mailed questionnaire it is assumed that these results were obtained under non-anxiety provoking conditions. This is of significance because the literature has suggested that differential birth order responses in terms of independence-dependence may be related to reactions to anxiety.

The results of the career choice analyses indicated that a subject's choice of a research or non-research career was related to his needs for independence-dependence more than his subject matter interest in science, and/or engineering, or non-science. Subjects who selected careers involving some research were found to be more autonomous than non-researchers. Within the general research group, however, those who planned to emphasize research (with or without some teaching) were more autonomous than those who planned to emphasize teaching with some research. The teacher-researchers were more deferent, nurturant, and desirous of succorance as might be expected from their role, than those emphasizing research or the non-researchers. The research emphasis group was, however, more deferent, nurturant, and in need of succorance than non-researchers. This may be explained by the fact that many in this group desired to do some teaching. There was a trend for administrator-researchers to be the least autonomous of the general research group but more autonomous than the non-researchers. The administrators were also the least deferent, nurturant and succorant of all the groups. This may be a function of the fact that these 3 dimensions are negatively correlated with dominance (Edwards, 1959), which is usually associated with choice of the administrator role.

There was a slight trend for scientists in most research categories and the non-research category to be a little more independent than their non-scientist counterparts. Differences in independence-dependence — particularly qualitative differences -- should be studied in subjects with various subject matter interests.

[illegible] choice results of this investigation — particularly those on autonomy support Cattell and Drevdahl's (1955) findings with eminent scientists (biologists, physicists, and psychologists) that researchers and teachers were more self-sufficient than the general population or an undergraduate university student sample. Researchers were more self-sufficient than teachers but teachers scored higher on the quality than administrators. The subjects in this study were beginning their careers, however, and were not yet eminent. The fact that these differences appeared at this stage in career development would indicate that in terms of the subjects' expressed needs for autonomy the career choice emphasis is the important factor.

Analyses of the subjects' independence-dependence scores in terms of both birth order and career choice yielded 2 significant interactions. The difficulty of discovering patterns in the relationships and a statistical consideration previously noted led the investigator to place very little confidence in these findings. Some analyses of variance did yield supporting main effects and knowledge of both birth order and career choice information about subjects was helpful in explaining the variance in independence-dependence scores. Since the interaction was not significant it cannot, however, be said that the subjects' scores were dependent upon the interaction of these variables.

Although there is still much to learn about independence-dependence in subjects of various birth order and career choice classifications, the lack of relationships revealed in Part I and the absence of meaningful interactions in Part II have led to the conclusion that future investigations need not study or relate birth order and scientific career choice in terms of independence-dependence. It would be more profitable to study this domain in relation to birth order and career choice separately. Independence-dependence should be studied as it functions on different levels of personality. The same sample should be subjected to questionnaires, experimental situations, and projective tests. This would enable us to learn how dimensions of independence-dependence function within the individual and within birth order and career choice groups.

APPENDIX E

THE RORSCHACH TEST

by

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That there are individual relationships between personality and the role the occupation plays in the life of the individual has been found repeatedly in research studies, in therapeutic situations, and noted often in many biographies. A problem of vocational psychology is to determine whether or to what extent such relationships can be generalized beyond the individual case. A natural question would be, "Are there detectable personality patterns which are more closely related to some occupations than to others?" All attempts at vocational guidance which use any personality measures assume that such relationships exist, but much needs to be done in order to have clear and replicable studies in this field. The use of the Rorschach Test in the Scientific Careers Study was an attempt to follow up on the many fragments of evidence that appear in the research literature.

The extent of testing 689 subjects with individual Rorschachs represents an enormous amount of financial and individual effort. It was after convincing promise was detected in the literature, and after many of the previous shortcomings of dealing with Rorschach scores were overcome, that it was decided to use the Rorschach Test as a sample of personality behavior for purposes of studying career development.

A widespread method of assessing personality is through the manner in which an individual structures his environment. This is usually accomplished with projective techniques. Of the several techniques available, the Rorschach Test is often considered very effective for this purpose. The clinician has used the Rorschach with apparent success in his study of individual personality dynamics. Its utility in this respect has led to its adoption in studying the various aspects of career development. The assumption is that by allowing the individual to structure his environment, the Rorschach in this instance, he will reveal his reactions to both internal and external pressures as they might influence his career development.

The Rorschach Test is a procedure in which the subject actively and spontaneously gives structure to ambiguous ink-blots, by which it is implied that he reveals the structuring principles which are the principles of his psychological organization (Rapaport, Gill, & Schafer, 1946). The use of the Rorschach assumes that the individual does not know or is unable to provide the answers sought by giving the test, otherwise he could be asked directly. The basis on which the Rorschach rests is that the "total personality" as reflected in the test is a description of the manner in which separate aspects of personality form interrelationships to make up "the personality." The Rorschach makes its contribution by assessing the functional relationships between aspects of personality, and not their isolated meaning. The test also attempts to discover the extent to which the person is utilizing his capacities, and how these capacities are related to his personal factors. The Rorschach has a contribution to make in the study of personality, and this requires the consideration of its use in the study of career development.[1]

The Rorschach Test

Complete descriptions of the Rorschach Test can be found in several sources (Beck, 1949; Klopfer et al., 1954; Rapaport, Gill, & Schafer). Much of the previous research with the Rorschach has been accomplished with modified forms of the test procedure, such as group testing, time limits, response limits, etc. However, users of modified forms agree that adaptations of the Rorschach Test are at the expense of the quality and kind of information obtained. Whenever the term Rorschach or Rorschach Test is used herein, it will refer to the standard procedure involving administration, inquiry, and scoring on an individual basis for each subject that took the test.

Research with the Rorschach reveals several major problem areas in the use of the test, such administration, scoring, and statistical analysis.

ADMINISTRATION

The conditions under which a test is taken can significantly affect the results, but this aspect of testing is often taken for granted. Projective tests are especially susceptible to the administration and conditions of testing. In spite of the evidence showing the importance and significance of the administration of the test, very few studies discuss this aspect of the data collection.

The seven Rorschach interviewers all received their training in the same Social Relations course at Harvard University and were doctoral candidates. Practical concerns made it impossible to have the same interviewer for two of the four age levels involved in the SCS. However, interviewers were of the same sex and of similar age for any given age level tested.

Staff meetings were held before any tests were given in an attempt to standardize the administration and inquiry of the test, and to provide scoring comparability. All 10 Rorschach ink blots were presented to the subjects before inquiry was begun. All responses were recored by the interviewer and locations marked on the standard Rorschach scoring blank.

SCORING

The scoring was basically that of Klopfer and associates (1954), with the exception of using Beck's (1949) tables for F+ and F-. A scoring guide was prepared to supplement the Klopfer system and to clear up ambiquities (Mierzwa, 1959). Staff meetings were held prior to the testing to agree upon the scoring categories to be used. Each interviewer scored his own tests, and one investigator was responsible for re-reading all protocols for inconsistencies in scoring between the various interviewers. Where conflicts arose, a mutually agreed upon scoring was recorded.

The most ambiguous aspect of Rorschach scoring is that of determinants. The other scoring categories (location, content, and popular) are relatively objective and need a minimum of clarification. Research indicates that inter-scorer reliability can be improved by prior agreement upon procedures to be followed with the more subjective scores.

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[1] See (Mierzwa, 1959; Roe & Mierzwa, 1960) for reviews of pertinent research and suggested roles the Rorschach might play in the study of career development.

Another problem with Rorschach scores that has been frequently overlooked in research is the concept of additional scores. The particular type of additional score in question occurs when a response is made up of two or more determinant scores, and where the only basis for assigning the main score (score that is counted) is a priority system. The use of an arbitrary priority system seems inappropriate, especially when the other additional determinant scores are completely disregarded. The clinician uses these additional scores for his appraisal of the individual. A priority system that disregards information from additional scores represents a possible loss of significant data. One suggestion which has been made is that one-half credit be given to these additional scores to overcome this problem (Klopfer et al., 1954).

Another aspect of Rorschach scoring that has been often neglected is the use of content scores. Content of the responses is an extremely important aspect in the clinical application of the test, but has received little attention in most quantitative approaches to research. This investigation utilized a full complement of some 20 content scoring categories.

STATISTICAL PROBLEMS

Even though the research worker overcomes the problems of securing meaningful Rorschach scores, the statistical treatment of these scores can present problems. The scores of the Rorschach Test do not correspond to the more orthodox types of psychological test scores.

One major difficulty with Rorschach scores is the lack of normality in the distributions of the various scoring categories. Cronbach (1949) recommended converting the raw scores to T-scores in order to deal with the skewed distributions. However, the resulting scores have the limitation that tests of significance depending upon variance or comparison of means cannot be applied.

Eichler (1951) used the square-root transformation to normalize Rorschach raw scores and found it useful for analysis of covariance. This is a curvilinear transformation and is appropriate for skewed distributions. Mosteller and Bush (1954) have shown that Rorschach scores approach the Poisson distribution. They suggest that the Freeman-Tukey square-root transformation is the most appropriate and this is a refinement of the square-root transformation.[1] Rorschach scores have variances that depend on unknown true means, and this transformation results in new scores whose variances do not not depend on their means to any great extent. The variance of Poisson data is approxitely unity after the Freeman-Tukey transformation. This is important because one of the requirements of analysis of variance is that each cell of the original data must represent a normal population with the same variance, event though the means are not necessarily the same. In addition, tests of significance that depend upon variance are applicable. Because of these considerations, all of the scores for each subject were transformed using the Freeman-Tukey procedure.

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[1] $z = \sqrt{x} + \sqrt{x+1}$; where z is the transformed score and x is the observed count.

Another aspect of the Rorschach Test that has presented statistical problems is the influence of the total number of responses upon the various discrete scores. This becomes relevant if there is to be an attempt to compare individuals, or groups, when there are large differences in the total number of responses given by the individuals. Several studies have used % of total responses in an attempt to account for dependence on total number or responses. However, as Cronbach (1949) and Fiske and Baughman (1953) have indicated, the use of % scores is not adequete. Our solution of this problem will be discussed in the following section on factor analysis.

Factor Analysis

Up to 1959, there were only two factor analytic studies of the Rorschach Test with nonpsychiatric populations. Wittenborn (1950) used 21 of Klopfer's scoring categories with 92 Yale undergraduates. No attempt was made to transform the scores to adjust for skewness, and a centroid factor analysis was computed.

Wishner (1959) utilized a sample of 71 males and 86 females in the age range of 17 to 69. He used 20 of Beck's scoring categories with a centroid factor analysis. He converted raw scores into percentages to account for dependence upon total number of responses.

In another study, Eschenbach and Borgatta (1955) dealt with 125 Air Force men in the age range from 20 to 45. In addition to 15 Rorschach scoring categories, 25 non-Rorschach scores were included. The correlation matrix was factored by the centroid technique. However, some individuals with discipline problems were included, and this could significantly detract from this being considered a study of "normals."

Several problems are apparent with these studies — large age ranges, direct use of raw scores, too few scoring categories, and small samples. None of the factors resulting from the studies reviewed to be appropriate to use directly in this investigation. Therefore, it seemed reasonable to conduct our own factor analysis of the 689 Rorschach protocols which had been obtained from the subjects of the Scientific Careers Study. The differences in the four groups necessitated separate treatment for each group — the groups ranging in size from 142 to 213 (see Table E1).

There are several alternative procedures available for factor analyzing a given correlation matrix. Since we were primarily interested in defining the minimum dimensions needed to describe the variance in the original Rorschach scores, it was decided that principal components analysis would be the most appropriate approach. The centroid method, which was the method generally utilized in previous Rorschach investigations, is simply a computational compromise for the principal components solution. Since a high speed digital computer was available the compromise was unnecessary.

The principal components analyses were conducted using unities in the diagonal, following the recommendation of Kaiser (1960). In addition to the advantages pointed out by Kaiser, the analysis of the total variance simplifies two subsequent operations — deciding onthe number of significant factors and the computation of factor scores. The more elegant procedures available for estimating the communalities would not change these results substantially, and they would have made our primary objective more difficult to achieve. That objective was simply to be able to describe the individuals in a factor space of about fifteen dimensions rather than requiring the forty or more dimensions of the original test space.

After the four sets of principal components were extracted varimax rotations were conducted. Rotation was done in the hope that the varimax factors would make the interpretation of criterion group differences less difficult. The varimax solution proved unsatisfactory. The nature of the varimax criterion is such that general factors, if originally present in the principal component solution, tend to be "destroyed" during rotation. Because the Rorschach responses very definitely exhibit a general factor (productivity), this property of varimax rotation was undesirable.

In using the Rorschach quantitatively, the results are more interpretable if one partials out the general response factor. The initial principal component solution seemed to accomplish just this by having a general productivity factor independent of the other factors. During varimax rotation, however, much of the variance associated with the first factor was distributed to the other factors, thus causing a person's location on any dimension (factor) to be partially a function of the number of responses given. Therefore, the analysis was continued using the principal component factors, primarily for the following reasons:

(1) It was important to maintain a general response or productivity factor.

(2) The general factor and remaining bi-polar factors of the principal component solution seemed no more difficult to interpret than the varimax solution.

(3) The principal component factor scores were orthogonal in the original sample space, and uncorrelated factor scores would simplify the subsequent operations which were planned.

(4) Group separations in the varimax space would be identical to the separations produced in the principal component space.

A separate principal components analysis was conducted for each of the four sample groups. A general outline of the differences and similarities of these four analyses can be seen in Table E1. The 14 or 16 vectors with roots greater than 1.000 account for about seventy per cent of the variance in each of the four cases. With the exception of group 8, the general factor (productivity) accounts for about 19 per cent of the variance in the Rorschach scores.

TABLE E1

SUMMARY OF THE FOUR RORSCHACH FACTOR ANALYSES

	GROUP P			
	5	8	11	College
Grade Administered	5	9	12	14 & 16
Number of Subjects	142	152	182	213
Number of Variables	43	45	46	48
Number of Significant Roots	14	16	14	16
Per cent of Variance accounted for by the:				
Significant Factors	70.5%	72.6%	67.9%	69.0%
General Factory	19.8%	14.3%	18.1%	19.6%

The four sets of the 16 largest latent roots are presented in Table E2. The normalized vectors associated with these roots are converted to factor pattern coefficients (Tables E3 to E6) by multiplying each element of the latent vector by the square root of the corresponding root. Thus, the roots listed in Table E3 are the standard deviations for the corresponding factors. Only those principal components whose latent roots were greater than the variance for a standardized score (i.e., greater than 1.000) were preserved for further analysis. There are 14 factors for groups 5 and 11, and 16 factors for groups 8 and College. It can be assumed that the variance associated with the remaining principal components does not contain significant information for discriminating the groups of interest in the Scientific Careers Study.

The four tables E3 to E6 list the sets of factors for the four groups. Only those loadings greater than .30 are reported so that the factor pattern may be inspected and studied more efficiently. Using a procedure outlined in Harman (1960), the standard error of a factor loading was found to be .152. Therefore, a loading greater than .29 is significant at the .05 level, and a loading greater than .39 is significant at the .01 level.

TABLE E2

LATENT ROOTS FOR THE PRINCIPAL COMPONENT ANALYSIS

	GROUP			
Root No.	5	8	11	College
1	8.505	6.446	8.306	9.367
2	3.157	4.001	3.290	3.511
3	2.502	3.076	2.841	2.311
4	2.131	2.268	2.204	2.060
5	1.782	2.084	2.012	1.772
6	1.698	1.791	1.785	1.684
7	1.589	1.671	1.754	1.614
8	1.480	1.597	1.553	1.474
9	1.420	1.522	1.453	1.354
10	1.378	1.391	1.381	1.290
11	1.295	1.282	1.264	1.206
12	1.207	1.267	1.175	1.155
13	1.142	1.135	1.150	1.107
14	1.063	1.091	1.063	1.079
15		1.057		1.021
16		1.007		1.002

TABLE E3

GROUP 5 RORSCHACH PRINCIPAL FACTOR PATTERN*

	FACTORS													
Variable	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
1 R	948													
3 D	768		311											
4 Dd	731	-468												
24 Obj	720													
31 N	654						302							
26 Hd	596	-394												
8 S	561				-353									
27 Ad	554	-498												
20 C,CF	542		-386			393								
6 F-	542							326		371				
18 FC';C'F,C'	513					383								
12 Fm	512				-338									
14 K,KF	499			-508										
15 FK	485												-377	
16 Fc	484			333										
10 FM	481		409											
25 H	479	563	324											
9 M	446	558	364											
11 m,mF	439		-314									342		
19 FC	439	321												
43 Cloth	420			-316										
5 F+	378				343					438				
42 Expl	363		-407			-327								
30 Bot	356			309			436	-388						
41 Smoke	348		-330	-331										
2 W	331	630		380										
17 cF,c	319				386			-389	372					
35 Cloud	304			-422	305						-347			
22 Rej	-337				-305									
7 W		458							-301	-417				348
21 P		387	477											
37 Fire		307									346			
32 Geo		-302						416						373
33 Art			-482											
38 Color			-460			581								
39 A.At				476										
29 At					321							-589		
28 Aobj					310		-344	439						
40 Food						384				312				422
34 Embl						-310					626			
36 Blood							-483							
23 A									-541					
13 Fk,kF,k											343			

*Only loadings greater than .300 are included and the decimal points have been dropped.

TABLE E4

GROUP 8 RORSCHACH PRINCIPAL FACTOR PATTERN*

	FACTORS															
Variable	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
1 R	895	-394														
20 CF	612	391										-344				
29 Obj	599					-301										
10 Fm	596															
9 m,mF	586	467														
4 D	534	-626														
31 N	522				-361											
44 Expl	496	386						-432								
2 W	473		-331						425							
16 Fc	470						-378									
19 FC	460									380					-480	
6 S	420		434		312											
4 Dd	413						-343									
15 F-	412	-367	308				337									
45 Cloth	403			305	-341											
13 FK	394			-308		-371										
39 Abs	375			344												-325
33 Art	370			413												
30 Bot	353											-347				
24 Hd	341	-349			-333											
37 Fire	328	428									-436			-338		
18 FC;C'F	313					315		393								
25 A	313	-614														
32 Geo	301		375		385								-304			
22 Rej	-534															
12 K,KF		489		-463												
43 Smoke		451		-373				349								
14 F+		-696					349									
21 P		-478	-386													
26 Ad		-351			-308											
11 Fk,kF,k			427				-339									
35 Cloud			327	-321					371				489			
7 M			-784													
23 H			-711													
8 FM			-373			376				324						
34 Embl				367		348		-403								
36 Blood				365				-468								
41 A.At				320				371			-378			376		
42 Food				310	354				-306							
27 Aobj				300	344				428							
17 c,cF				300	-391						397					
3 W					453				-439					-354		
40 Color						376						-566				
28 At							-464			-338	355					
38 Mask														-418	350	-335

*Only loadings greater than .300 are included and the decimal points have been dropped.

TABLE E5

GROUP 11 RORSCHACH PRINCIPAL FACTOR PATTERN*

	FACTORS													
Variable	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
1 R	-963													
30 Obj	-663													
4 D	-641	-385	363											
32 N	-621						411							
14 F+	-610		353											
5 Dd	-578													
20 CF	-565	418												
6 S	-549													
25 A	-513	-467												
15 F-	-506												-306	
2 W	-495			420										
8 FM	-493	-366												
19 FC	-487							330						
10 Fm	-452				-326									
26 Ad	-452		404											
45 Expl	-428	517												
31 Bot	-421						370		-386					
43 Food	-419									465				
9 m,mF	-405	594												
21 P	-404	-522	-330				-337							
36 Cloud	-398	472												400
38 Fire	-398								319				302	
23 H	-391		-611		363									
16 Fc	-376			463										
17 c,cF	-361						405							
13 FK	-338			-337						-338				
37 Blood	-333										343	-515		
33 Geo	-326		532											
40 Abs	-321	366			453									
3 W	-311		-396										-410	
22 Rej	623													
44 Smoke		416					-437							
12 K,KF		369					-358				-352			
11 Fk,kF,k		310	357	328					-352					
24 Hd		-338	311		474									
46 Cloth		-305					314							302
28 At			407			-338								
7 M			-683		371									
27 Aobj				618					323					
41 Color				367								424	-302	
34 Art				324	-486									
35 Embl						397	-307							
18 FC;C'F,C'						373		-377	-444					
29 Sex						-572								
42 A.At						-479								
39 Mask								328				353		

*Only loadings greater than .300 are included and the decimal points have been dropped.

TABLE E6

COLLEGE GROUP RORSCHACH PRINCIPAL FACTOR PATTERN*

Variable	FACTORS I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
1 R	-957															
4 D	-766	-366														
31 Obj	-679															
5 Dd	-649															
26 A	-633	-310														
15 F+	-618		-431													
27 Ad	-591	-426														
20 FC	-591															
17 Fc	-586															
10 Fm	-552													386		
6 S	-536							-342								
21 CF	-516	415														
33 N	-498	363														
2 W	-492	327					-340									
32 Bot	-481			-345												
8 FM	-463	-304	463													
19 FC;C'F	-462															
22 P	-453		313													
16 F-	-446		-540													
9 m,mF	-424	529		322												
7 M	-418	-467		445												
37 Cloud	-411				338											
24 H	-407	-521		357												
14 FK	-403						320									
34 Geo	-402		-413									376				
25 Hd	-397	-467														
13 K,KF	-386	466							362							
18 cF,c	-356										464					-305
47 Cloth	-335			420				349								
38 Blood	-313					428										
29 At	-312			-428	-436											
11 k,kF	-301							-389				304				
23 Rej	400														-480	
46 Expl		566														
35 Art		433				331										
45 Smoke		388					-391									
40 Mask			-308			471										434
12 Fk				-332						345					358	
36 Embl					423				-367							
30 Sex					-614											
44 Food					-374			347				382				
42 Color						445					-319					-362
43 A.At							328		321							
28 Aobj								328	-307					352		
3 W								-308					459			
41 Abs									-438			-313				
39 Fire										-366		300				
48 Sym												392	416			

*Only loadings greater than .300 are included and the decimal points have been dropped.

Discriminant Analysis

Once the original Rorschach test space was reduced to a factor space of either 14 or 16 dimensions, the task of determining the validity of the factor space remained. That is, do different criterion groups occupy different regions of the factor space? The predictive validity of the Rorschach was first explored by conducting a discriminant analysis for the college group.

The college students selected for participation in the Scientific Careers Study were male sophomores and seniors majoring in one of the natural sciences or engineering. There are three criterion groups based upon career plans which are relevant to this study which the Rorschach might distinguish. The groups include:

(1) Research Group — those who plan to enter graduate work in science and expected to conduct fundamental research as part of their future work;

(2) Applied Science Group — those who plan to continue in science and engineering, but who do not plan a research career;

(3) Non-Science Group — those who plan to leave science work and enter fields which usually have a more direct involvement with people.

The groups were initially determined by sorting the individual students into one of the three groups on the basis of their post-college career plans.

Some classification problems arose regarding those who entered medical and dental schools. Previous experience indicated that dentists, in terms of personality information, resemble engineers. Therefore, dentists were classified with the Applied scientists. Those entering medical school are a rather heterogeneous group. Many indicated a definite research interest, and were placed in the Research Group. Those deciding to enter medical practice were classified in the Non-Science Group. They expressed a primary orientation toward people, as revealed in their stated career goals and in general personality characteristics of doctors. All other classifications were generally straight-forward, and the sorting was checked by both investigators.

A three-group discriminant analysis was conducted using the sixteen factor scores for the college seniors (N = 99). Since there were three criterion groups, only two (G - 1) discriminant functions were required to describe the group differences. The means of the three groups on the sixteen factors and the relative contribution of each factor to the two discriminant functions are found in Table 7. It can be seen that factors 2,8, and 14 made major contributions to discriminant function I, whereas factors 1,6, and 12 contributed largely to function II. At the bottom of Table 7 are the non-zero latent roots, which are the variances for the corresponding discriminant functions.

Wilks' Λ_w criterion provides a basis for estimating the probability that these groups are random samples from a common multivariate population. The results of this test of significance are presented in Table E7. The probability associated with the derived F ratio indicates that the three groups have discernable personality differences, as measured by the Rorschach test (significant at the .025 level).

INTERPRETATION OF THE RESULTS

There is a temptation to look back at the group separations produced and show how easily they are explained (or how easily they could be anticipated!). However, to borrow from Rorschach, "The conclusions drawn (from this report)are to be regarded more as observations than as theoretical deductions. The theoretical foundation for the experiment is, for the most part, still incomplete."[1] The emphasis in this report will be upon the observed trends. A theoretical framework for the general results of the Scientific Careers Study is emerging, but its exposition is awaiting cross-validation by overlapping groups.

To explore the "what happened?" in this discriminant analysis one needs to inspect four trends sequentially.[2] This will be illustrated by examining some of the

TABLE E7

SCALED DISCRIMINANT VECTORS AND GROUP MEANS FOR THE SIXTEEN COLLEGE FACTORS

Factor No.	Scaled Discriminant Functions I	II	Research N = 33	Applied N = 28	Non-science N = 38
1	.200	.472	-2.328	2.364	-1.809
2	-.515	.296	1.127	.188	-1.224
3	-.038	.037	-.138	-.075	-.441
4	.105	-.358	.181	-.310	.389
5	.056	-.227	-.041	-.148	.284
6	-.111	-.462	.271	-.460	.180
7	-.194	.166	.309	.142	.003
8	-.557	-.244	.487	-.187	-.029
9	-.013	-.028	-.089	.036	-.188
10	.390	.314	-.515	.286	.161
11	-.385	-.029	.486	-.127	-.029
12	.174	-.403	-.102	-.216	.188
13	-.301	.026	.272	-.042	-.103
14	-.604	.267	.141	.061	-.482
15	-.130	-.191	.121	-.072	-.100
16	-.045	.145	.032	.124	.013

LATENT ROOTS

Root	Per Cent of Trace
$\lambda_1 = .407$	69%
$\lambda_2 = .179$	31%

$$\lambda_1 + \lambda_2 = .586$$

Trace of W A = .586

Wilks' lambda = .603 F = 1.73 $p < .025$

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[1] Rorschach, H. Psychodiagnostics. Bern: Hans Huber, 1932. (Transl. by P. Lemkau and B. Kronenburg. New York: Grune & Stratton, 1942. P. 13).

[2] At times a complicated task, but not nearly as difficult as examining the 48 Rorschach variables "simultaneously" as would be necessary without multivariate analysis.

the major reasons for group separations on the first and second discriminant functions. The scaled discriminant vectors in Table 7 reveal the relative contribution of the factors to the group discriminations. The first "high" loading (either positive or negative) encountered in going down the column representing Discriminant Function I is -.515 for Rorschach Factor 2. The three group means for Factor 2 (see Table 4) indicate that the Research group has the highest mean, the Non-Science group lowest, and the Applied Science group is between them. Because Factor 2 has a negative loading on Discriminant Function I, the Research group, which is high on Factor 2, tends to be at the negative end of Discriminant Function I.

The next step is to determine the types of Rorschach responses that must be given by an individual to be high on Factor 2. This information is found in Table E 6 (College Group Rorschach Principal Factor Pattern). A high Factor 2 score indicates a tendency to give the following types of responses: Expl, m-mF, K-KF, Art, CF, C, Smoke, N, and W. In addition, a high Factor 2 score also indicate a tendency not to give responses of: H, M, Hd, Ad, D, A, and FM. Therefore, the Research group tended to give more responses of the first type, and the Non-Science group tended to give more responses of the second type.

The above trends demonstrate that the Non-Science group tended to perceive humans and animals, especially in motion, and the Research group did not. On the other hand, the Research group responded with various forms of inanimate movement and perceived content involving force and natural phenomena. The Research group also tended to perceive diffuse shading, color, and art objects. Simply in terms of the perceptions involved, this bi-polar factor might be termed inanimate (+) vs. animate (-). Certainly on the surface this result "fits" the generalization previously established that scientists have a general orientation which is not toward people.

The same sequence can be applied to Discriminant Function II. In this case, the highest loading (.472) is for Factor 1 (see Table 7). The Applied Science group has the highest mean on Factor 1 and the Research group has the lowest. Being high on Factor 1 is therefore part of the reason why the Applied group is high on Discriminant Function II as observed in Figure 1.

The college principal factor pattern in Table E 6 is again used to determine the Rorschach response pattern which is associated with Factor 1. This factor is clearly the general productivity factor, its correlation with R (total number of responses) being almost perfectly negative (-.957). Therefore, high Factor 1 scores indicate low productivity, and low factor scores result from high productivity. Other analyses of the Rorschach have suggested that productivity is related to general intelligence.

The trends on the other factors which contributed to the group discriminations can be found in the same manner as was done above for Factors 1 and 2. These trends are summarized in Tables E8 and E9.

The primary purpose of this Appendix has been to summarize the data reduction of the Rorschach protocols, and to report there are discriminant analysis involving the Rorschach which proved to be significant statistically. It is an interesting point to note that this was the first analysis attempted in this investigation using the Rorschach.

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[1] Factor 1 would be more easily discussed if the signs of the loadings had been reversed. The factor scores had been computed with the signs as reported, and the negative relationship was retained to be consistent.

TABLE E 8

TRENDS PRODUCING THE GROUP SEPARATIONS

DISCRIMINANT FUNCTION I

Factor *	Associated Rorschach Variables	Group Means	
	(+) Expl, m, mf, K, KF, Art, CF, C, Smoke, N, W	Research	1.127
2		Applied	.188
(-.515)	(-) H, M, Hd, Ad, D, A, FM	Non-Sci.	-1.224
	(+) Cloth, Food, Aobj	Research	.487
8		Non-Sci.	- .029
(-.557)	(-) k, kF, S, W	Applied	- .187
	(+) Fk	Applied	.286
10		Non-Sci.	.161
(-.390)	(-) Fire	Research	- .515
	(+) c, cF, A.At	Research	.486
11		Non-Sci.	- .029
(-.385)	(-) Color	Applied	- .127
	(+) Fm, Aobj	Research	.141
14		Applied	.061
(-.604)	(-) Embl, C', FC', C'F	Non-Sci.	- .482

TABLE E 9

TRENDS PRODUCING THE GROUP SEPARATIONS

DISCRIMINANT FUNCTION II

Factor	Associated Rorschach Variables	Group Means	
	(+) Rej (Number of cards rejected)	Applied	2.364
1		Non-Sci.	-1.809
(.472)	(-) General Productivity	Research	-2.328
	(+) M, Cloth, H, m, mF	Non-Sci.	.389
4		Research	.181
(-.358)	(-) At, Bot, Fk	Applied	- .310
	(+) Mask, Color, Blood, Art	Research	.271
6		Non-Sci.	.180
(-.462)	(-)	Applied	- .460
	(+) Sym, Food, Geo, k, kF, Fire	Non-Sci.	.188
12		Research	- .102
(-.403)	(-) Abs	Applied	- .216

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* Under the factor number is the discriminant coeficient for that factor. It is important to keep their signs in mind when comparing these results to the group centroids plotted in Figure 1.

APPENDIX F

COMPUTER PROGRAMS

The development of the following programs was partially supported by this research project. They are available in Cooley and Lohnes (1962) and are on tape at the Harvard Computer Center. The principal programmers involved were Paul R. Lohnes, Kenneth J. Jones, and William W. Cooley.

DISCRIM	Multiple group discriminant functions
CORREL	Correlation matrices for up to 50 variables
R-CLASSIF	Reduces original matrices to discriminant space and computes probabilities of group membership
MULT R	Multiple regression analysis
COVAR	Analysis of variance with covariance adjustment
CANON	Canonical correlation analysis
FACTOR	Factor analysis
STEPR	Stepwise multiple regression analysis